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IRVINGTON SANITARY SURVEY;

AN EXAMINATION

AS TO LOCAL CAUSES OF FEVER AND AGUE ON THE
EAST BANK OF THE HUDSON RIVER FROM
DOBBS' FERRY TO TARRYTOWN,

WITH

RECOMMENDATIONS FOR IMPROVEMENT.

BY

GEO. E. WARING, Jr.,

Consulting Engineer.

Illustrated by a Topographical Sketch Map,

By E. C. METCALF,

Assistant.

ALSO,

Suggestions for the Sewerage of Irvington Village.

New York.

1879.

Hygiene, Public

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IRVINGTON SANITARY SURVEY.

CYRUS W. FIELD, ESQ., PRESIDENT,

Dear Sir :

I submit, herewith, a final report concerning the district with whose examination I have been entrusted, and a map showing such of its features as seem to me to have a bearing on its sanitary condition. This map is based upon one published by M. Dripps, which is a collation of surveys made by Messrs. Ward, Carpenter & Son, Tarrytown. Its general measurements are assumed to be correct; but the various topographical features here introduced are to be regarded only as a careful sketch, not as a survey founded on actual measurements. It is sufficiently accurate to serve the purpose of a minute memorandum, which is its only object.

I republish, herewith, parts of my preliminary report, made after a hasty examination in June.

PRELIMINARY REPORT.

My observations were made chiefly with reference to fever and ague malaria. It must be stated at the outset that we are practically without knowledge as to the causation of this disease. There are, however, grounds for adopting a somewhat definite theory about it.

It seems clear that, to a certain extent, the disease, which may originate in specially unhealthful places, propagates itself slowly through human agency. It is a well-known fact that it has gradually spread from its earlier centers, and extended for a long distance into districts where it was previously unknown. Instances of this are too well known to need recounting.

In like manner, districts where the disease formerly prevailed, and where it had originated spontaneously, have, by drainage, been made

perfectly healthy. For example, the fens of Lincolnshire, in England, and marshy districts along the lower Thames, were formerly greatly scourged with fever and ague, and with malarial neuralgia. The extensive drainage operations carried on in these districts have had the effect of removing these ailments entirely from wide districts where they had formerly prevailed with the greatest severity.

The investigations thus far made lead to the following belief concerning the point which chiefly interests you and your neighbors: assuming that fever and ague is indigenous, or that it has been brought to a locality by the movement of population, it seems clear that it propagates itself only under the influence of certain conditions of atmosphere which are produced by undue soil moisture, by the excessive decomposition of vegetable matter, and by the stagnation of the air caused by dense planting and the absence of sunlight.

Assuming, as I believe one may safely do, that fever and ague is not indigenous in the Irvington neighborhood, but has been brought to it, so far as it exists there, by the importation of cases of the disease, we have to look for such local conditions as would foster it and lead to its reproduction and localization.

So far as my examination warrants me in forming an opinion, I should say that there do exist, more or less throughout the whole district examined, sufficient resting places for the infection, associated with conditions which would naturally lead to its propagation. I think it may be safely assumed that a detailed examination of the ground would lead to the discovery of these unfavorable spots, and that it is possible to remove them. At the same time, it must be understood that this opinion is not based on positive knowledge, for such knowledge does not exist. All that it is safe to say is, that, judging from the previous experience of the world, proper efforts would, in all probability, result successfully.

There are two leading items which have influence on this question: Drainage and Ventilation.

DRAINAGE.—Except along the river, and about certain ponds, some distance east from Broadway, there are few especially wet areas, but there are very many points where small bits of ground are too wet, and these are quite frequently so shaded from the sun as to be more than suspicious. Also, the prevailing passion for ponds, which often follow each other in quick succession along the lines of the brooks, is not without its bad influence. These ponds are often much too high with reference to the surface of the ground adjoining them; they are subject to become filled with silt and leaves; they are not always well supplied with fresh water, but are frequently fed with water from swamps about which it would be unsafe to live; and the brooks supplying them receive a good deal of organic matter in the form of leaves, etc.; in addition to all this, the filtration from these ponds is sometimes a source of a springy condition of the ground lying below them.

There are still some small areas and some large ones which, in the interest of the whole neighborhood, ought to be thoroughly drained.

I judge that about one-half, or nearly that of the whole shore from Tarrytown to Dobb's Ferry is swampy for a greater or less width, the small bays cut off by the railroad being imperfectly drained, receiving much water from the upland, being subject to the rise and fall of the tide, and often having considerable stretches of their bottom entirely uncovered.

All of these conditions are unfavorable.

VENTILATION.—Perhaps ventilation is not precisely the word to express what is here meant, except in the sense that what is needed is an abundant supply of fresh air and sunlight. The decomposition of organic matter in or upon a damp soil takes on a very different character, according as it is freely exposed to the circulation of air and to the sun's heat, or is covered either by water, by fallen leaves, by underbrush, by dense planting or by anything which may seclude it from the most active oxidizing influences.

It is an old but mistaken idea that it is hard to grow a tree and easy to cut one down. The reverse of this proposition is nearer the truth. Wherever prosperous humanity establishes itself, there seems to spring up, as if by magic, a cloud of leafage and a dense growth of all manner of arborescent vegetation, while every appeal, having for its purpose the restraining of this ground-cumbering growth, is met by the most persistent opposition. Not only will trees and bushes and shrubs multiply and shut out acres upon acres from the sun's rays and turn aside every breath of air, but the trees and bushes and shrubs accumulate until they destroy each other's beauty to that degree that plantations fifty years old have generally lost their distinctive and picturesque character, and become a mass of cramped forest trees, without lower branches, or shrubberies in which no individual plants can be seen;—only a mass of uninterrupted surface leafage. Any one who will examine a country seat, which was noted for its fine planting fifty years ago, will find that unless it was especially fortunate in having a skillful landscape gardener for its owner, it has lost its landscape beauty and has become more like a bit of primeval forest with bits of neglected undergrowth.

With due deference to one's present fondness for ample planting, and to the general disposition not to sacrifice this year's beauty for next year's gain, I must say that, in my judgment, at least, one-half of the problem in question might be solved by a rigorous and vigorous use of the axe. I believe, too, that if this were judiciously done, not only the future, but the present, beauty of the whole region would be as much improved as would its healthfulness.

If a further examination is made, it would be important to examine the condition of the land immediately above the aqueduct, to determine the extent to which water from the lands up the hill is

held back. It would also be well to inspect the upper part of Sunnyside brook.

Incidental to the foregoing, is the general question of the sanitary drainage of the more thickly settled parts of Tarrytown, Irvington and Dobbs' Ferry. Unquestionably, those villages are generally subject to the same sort of objections which prevail in villages throughout the country, and, to a certain extent, any effort to improve them in this respect would have a tendency to lessen any liability to fever and ague that may exist.

The chief purpose of such drainage, however, would relate to the reduction of typhoid fever, diphtheria and other zymotic diseases. This is somewhat apart from the immediate question at hand, but it is a promising field for investigation.

In addition to the conclusions set forth in the above, it seems desirable also to state the general considerations or theories upon which my recommendations for improvements are based, and to give somewhat fully the basis of my belief that the execution of the work herein recommended, *in its entirety*, together with such local treatment as may be required on individual places, will result in the removal of any existing local malarial conditions. It will not prevent such occasional cases as may result from the breaking up of any considerable amount of land—in the construction of roads, the alteration of grades, etc. Probably all districts which have once suffered from fever and ague, will always, no matter what their improvement may be, be subject to temporary outbreaks as the result of extensive disturbances of the soil.

I have observed, since the beginning of the discussion concerning this work, a curious confusion of ideas as to the cause of malaria and the means for its prevention. In this case, as in others of an occult nature, the positiveness with which opinions are expressed and criticisms made, seems to be in inverse ratio to the possession of knowledge on the subject. More than once, *ex-cathedra* statements have been advanced by members of the medical profession with a confidence that should result only from knowledge which nowhere exists.

For more than two thousand years, malarial diseases

have been known, and probably studied and discussed. The outcome of it all is, that at the present day we *know* absolutely nothing whatever about their ultimate origin. We have theories and speculation and well-founded hypotheses. Observations of conditions which have existed and of effects which have coincided with them, as well as of ameliorations which have coincided with the change of conditions, lead to the belief that the removal of what we consider the causes will result in the removal of the effect. This much seems sufficiently reliable to justify the effort, in any case like the present, to remove the probable sources of malaria. Perhaps it would be safe to go farther and say that while we cannot recognize the manner in which the cause of the disease operates, nor the manner in which this cause is generated, nor, indeed, what the cause is, we do know by observation that it is very generally an accompaniment of certain conditions which, so far as the soil is concerned, we have it in our power to remove.

Dr. Bartlett, in his work on the fevers of the United States, says: "The essential efficient producing cause of periodical fever—the poison whose action on the system gives rise to the disease—is a substance or agent which has received the name of *malaria* or *marsh miasm*. The nature and composition of this poison are wholly unknown to us. Like most other analogous agents, like the contagious principles of small-pox and of typhus, and like the epidemic poison of scarlatina and cholera, they are too subtle to be recognised by any of our senses, they are too fugitive to be caught by any of our contrivances.

* * * * *

"Inscrutable, however, as the intimate nature of the substance or agent may be, there are some few of its laws and relations which are very well ascertained. One of these consists in its connection with low or wet or marshy localities. This connection is not invariable and exclusive; that is, there are marshy localities which are

not malarious, and there are malarious localities which are not marshy, but there is no doubt whatever that it generally exists."

The best general statement of the case is that made by Dr. Metcalf in his report to the United States Sanitary Commission. He says that all hypotheses, even the most plausible are entirely unsupported by positive knowledge; and continues:

"This confession of ignorance still leaves us in possession of certain knowledge concerning malaria from which much practical good may be derived.

"1st. It affects by preference low and moist localities.

"2d. It is almost never developed at a lower temperature than sixty degrees Farenheit.

"3d. Its evolution or active agency is checked by a temperature of 32 degrees.

"4th. It is most abundant and most virulent as we approach the equator and the sea coast.

"5th. It has an affinity for dense foliage, which has the power of accumulating it when lying in the course of winds blowing from malarious localities.

"6th. Forests or even woods have the power of obstructing and preventing its transmission under these circumstances.

"7th. By atmospheric currents it is capable of being transported to considerable distances—probably as far as five miles.

"8th. It may be developed in previously healthy places by turning up the soil, as in making excavations for foundations of houses, tracks for railroads, and beds for canals.

"9th. In certain cases it seems to be attracted and absorbed by bodies of water lying in the course of such winds as waft it from the miasmatic source.

"10th. Experience alone can enable us to decide as to the presence or absence of malaria in any given locality.

Dr. Chadwick says: "In considering the circumstances, external to the residence, which affect the sanitary con-

dition of the population, the importance of a general land drainage is developed by the inquiries as to the cause of the prevalent disease to be of a magnitude of which no conception had been formed at the commencement of the investigation. Its importance is manifested by the severe consequences of its neglect in every part of the country, as well as by its advantages in the increasing salubrity and productiveness wherever the drainage has been skillful and effectual."

La Roche calls attention to the fact that "deposits of organic matter which are entirely covered with water (as at the bottom of a pond) are not productive of malaria; that this condition of saturation is infinitely preferable to imperfect drainage. That swamps which are shaded from the sun's heat by trees are not supposed to produce disease; and that marshes which are exposed to constant winds are not especially deleterious to persons living in their immediate vicinity."

Dr. Whitley closes his report to the Board of Health of Great Britain, 1864. "It would appear from the foregoing inquiry that intermittent and remittent fevers and their consequences, can no longer be regarded as seriously affecting the health of the population in many of the districts in which those diseases were formerly of a formidable character. Thus in Norfolk, Lincolnshire, and Cambridgeshire, counties in which these diseases were both frequent and severe, all the evidence except that furnished by the Peterborough Infirmary, and in a somewhat less degree in Spaulding, tends to show that they are at the present time comparatively rare and mild in form."

He makes the admission as regards England generally that "the diseases which have been made the subject of the present inquiry have been steadily decreasing, both in frequency and severity for several years, and *this decrease is attributed in nearly every case mainly to one cause, improved land drainage.*"

Colin, *Contes Rendus*, volume 77, page 1,075, says: that

if vegetable decomposition were the only cause of malaria its severe appearance would not be postponed until July, because already in June, vegetable decomposition is generally sufficient to produce offensive odors; that however foul swamp or pond water may be, the danger is less than after the water has disappeared leaving the soil bare; and that the drinking of swamp water has no specific action in producing malarial diseases. It is only a *cause banale* which diminishes the power of resisting morbid influences.

Dr. J. J. Woodward, *Camp Diseases*, referring to a statement of Dr. Watson, King's College, London, that "vegetable decomposition, although coinciding with the appearance of malaria, has no necessary genetic relation with it" says, that in any case, so far as the United States are concerned, vegetable decomposition "is one of the most important of the determining conditions."

Parke, in his *Manual of Practical Hygiene*, Second Edition, page 207, says that alluvial soils are worse than peaty soils, and that while the regular overflowing of land with salt water seems to be a source of safety, the occasional invasion of salt water, or *its admixture with fresh water overflows*, is pernicious and aggravates all the malarial conditions. He also says:

"Vegetation produces also a great effect on the movement of air; its velocity is checked, and sometimes in thick clusters of trees, or underwood, the air is almost stagnant, and if moist and decaying vegetation be a concordant condition of such stagnation, the most fatal forms of malarious diseases are produced. Vegetation may thus do harm by obstructing the movement of air. On the other hand it may guard against currents of impure air; the protective influence of a belt of trees is most striking.
* * * * Brushwood is almost always bad and should be removed. Trees should be removed with judgment. A decided pernicious interference with the movement of air should be almost the only reason for removing them."

Professor Dunglison says: "Our knowledge of all this matter seems to be limited to the fact that in particular climates and under certain unknown and inappreciable circumstances, the bottoms of our stagnant pools, mill ponds, marshes, etc., become miasmatic—a knowledge which we acquire by lamentable experience, and by that alone."

Referring to the prevalence of malaria along the shores of the Mediterranean, Dr. Johnson, Editor of the *British Medical Review*, says: "Ever since the days of Sir John Pringle, indeed, it has been admitted that the admixture of salt water with fresh, augments the disposition to the putrefactive process both in animal and vegetable matter."

Referring to the influence of the malarial agent when carried a long distance by wind, and, of course, greatly diluted, Macculloch says: "If the produce of 100 acres, more or less, can, in dilution of one thousand to ten thousand times, excite diseases, then must, in the inverse ratio, the produce of the thousandth, or the ten thousandth portion of that space be capable of producing the same effect." Also:

"The amount of the organic matter acted on by moisture in the soil may be so diffused as to present at no point a marshy appearance, while at the same time the health of the whole neighborhood may suffer without an adequate appreciation of the cause."

Concerning the period of the year at which works may be most safely executed, I quote the following from Dr. Macy's excellent lecture on Malaria: "On Paint Creek, in Ohio, a mill pond was generally drained on the first of June, and the rains of that month washed away the mud, etc., accumulated during the year. So long as this was done early in the season, and the dam immediately rebuilt, no serious results seemed to follow, and the inhabitants of Washington, the adjoining village, suffered but little from intermittents. One season, however, the draining was postponed until July, and no rains followed to

wash out the basin; there immediately followed an epidemic of autumnal fever which prevailed most on the side of the village next the pond. More than one-fourth part of the inhabitants suffered direct attacks from this epidemic, and about three per cent. of the entire population died of the fever."

One might continue to cite authorities almost endlessly. The foregoing seem sufficient to indicate the chief facts upon which our theories are based, and to indicate how far we are from the possession of absolute knowledge concerning this subject.

It is proper that I should formulate the hypothesis upon which I have based the following recommendation. My belief is as follows:

That the invasion of salt water to low lands along the river leads to an aggravation of the marsh miasm produced therein.

That accumulations of organic matter along the course of running streams, whether caused by slight obstructions of the channel, or by dams, may be decidedly deleterious.

That no body of water, large or small, may safely be retained, of which the level is subject to variation, for the reason that this variation exposes to the air the organic matter deposited along the water's edge, and generally in a state of saturation.

That while this is emphatically true concerning the actual exposure of organic deposits, it is relatively true with regard to deposits covered by so little water as to bring them within the influence of the sun's rays.

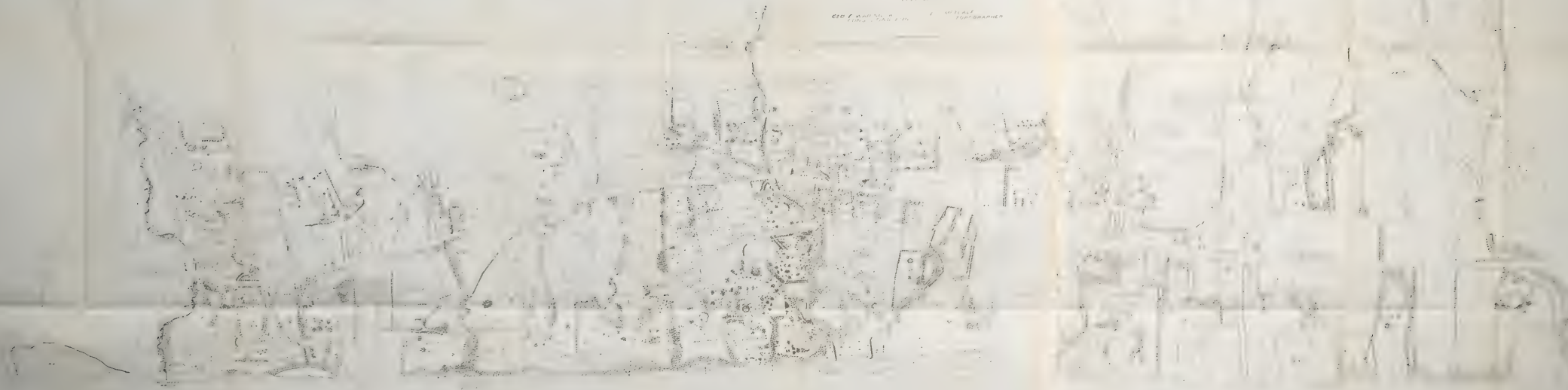
That even the obvious wetting of the ground by springs, by the exuding of water through the banks or dams of ponds, or by the too great width of the bottom of the ravine over which a brook runs, may be injurious.

That the accumulation of leaves, branches of trees, etc., in shaded spots may lead to danger.

That the stagnation of air is even worse than the stagnation of water, for the reason that the stagnant air

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is generally accompanied by the presence of decomposing organic matter, which is sufficiently damp for the worst results.

That while the heat of the sun may be a source of evil in the case of the saturated edges of a pond, and of accumulations of decomposing matter under shallow water, its influence upon the surface of dry ground can only be beneficial.

That drainage should in all cases be so complete that there can be no water of saturation in the soil nearer than two feet from the surface, except immediately after heavy rains.

On one point set forth in my preliminary report I find myself at variance with the authorities, *i. e.*, that fever and ague may propagate itself through human agency. My reasons for holding to this theory are that, long after all work of construction had been completed the disease has followed along the lines of railroads, with a development somewhat proportionate to the frequency of personal communication, and that almost universally it first appears in a new neighborhood in a very sporadic way, and gradually becomes intensified, until after a few years it takes on an epidemic character.

Dr. Henry Bronson, in his admirable "History of Intermittent Fever in the New Haven Region," communicated to the Connecticut Medical Society at its Annual Convention of 1872, shows that a gradual spread of the disease from the sites of scattered cases was general, if not universal, in the country examined by him. The following expressions, quoted from this paper, indicate conditions everywhere prevailing:

"It was not only more concentrated in its early seats, but its power of locomotion was greatly increased."

"It could not climb West Rock or Mt. Carmel range, perhaps because there were no inhabited houses to be used as stepping stones."

"Persons having * * frequent intercourse with the

city are liable to contract the disease on the way, especially when * * * they return home in the evening. In attempting to account for the malady in new or unusual, or unsuspected localities, this fact will, of course, not be forgotten."

Referring to "the old idea of Contagion," Dr. Bronson says: "It must be admitted that authority is opposed to this idea, but I do not think the question yet settled. If I mistake not it will again come up for decision—come up when opinion swings round, and the profession gets weary of current theories of ague-genesis."

"Out of a family of seven persons * * * six were attacked. The first case, however, was that of a child who attended the school at Allingtown. on which fact Mr. Leet, (the father) lays stress."

"From the same starting point the scourge (in 1870) traveled eastward across Dixwell, Ashmun, Canal, and Prospect streets, and appeared on Hillhouse avenue, and the high grounds of Sachem's ridge, the last, one hundred and thirty feet above the plain below." In the same paragraph he speaks of it as "the advancing enemy."

On the subject of the disease as connected with low, wet grounds, etc., he says: "This connection, if not uniform, is in this latitude not often wanting, especially in the first year of the disease;" and again:

"The world has had abundant opportunity to know that effectual and permanent drainage will, in temperate latitudes, often, if not always, mitigate or remove the marsh fever pest. Though the disease may break out and even become rife in places unprovided with bogs, mill ponds, and the like; though capricious in its movements, erratic and scandalously inconsistent, going where it should not, and refusing to go where it should: it cannot be denied that in its migrations, when free to choose, it *prefers* the bogs, etc. It has a natural affinity for them, searches them out, and finds near them a congenial home."

There is no *proof* that this disease may not, in a more

sluggish way, be communicated as typhoid fever is, by some agency produced by the body of the patient, which, under favoring local conditions, acquires the power of affecting a fresh subject. In the absence of such proof, this theory is at least as sound as that of *General Epidemic Influences*—a sort of vague wave of mysterious infection which sweeps over wide regions, and establishes malarial conditions where there exists no assignable new local cause. This seems to me to imply much less than a scientific method of reasoning. That unrecognized, but purely physical influences, do, now and again, awaken latent sources of malaria over wide regions is undoubtedly true; but, though thus far unrecognized, these influences are doubtless discoverable, and we can surely detect in advance the spots where the latent sources await them, and can so change the local conditions as to avert the visitation.

An apparent inconsistency will be observed in my treatment of the tree question. In certain cases it is recommended to remove nearly all trees from the vicinity of damp land. In others, the growth of willows, or other luxuriant vegetation is recommended for wet land; it is generally recommended that trees be not allowed to stand too thickly in the vicinity of houses, or pleasure grounds; and it is also recommended that belts of trees, and even of undergrowth, be encouraged along the borders of distant ponds and other remote sources of malaria. The idea is this: Land as dry as all land in the immediate vicinity of a house, or a pleasure ground should be, is not likely, if exposed to sun and wind, to produce malaria; it may be necessary to leave remote wet tracts, comparatively undrained, in which case a growth of a vigorous vegetation over and around them will, as has been shown by experience, modify, probably, the production of malaria, and certainly its diffusion. While it is deemed especially important that there be a free circulation of air about all dwelling houses and pri-

vate grounds, which circulation is interfered with by a profuse tree-growth, it is often desirable to fence off the extreme borders of our district by a barrier of forest growth, which will hinder the transmission of malaria produced beyond it.

Aside from the specific directions given under different headings in the following report, it is to be remarked in a general way, and as applying more or less to the whole district under consideration, that each owner should see to it, that there remains upon his property no spot of land which is unduly wet; that all ravines which are springy, or through which there are at times rills of water running, should be so opened to the sun, and to the circulation of air, that the atmosphere within them may be as dry and fresh as that of the hills beside them. While there can be no objection to rows and avenues of trees trimmed sufficiently high for the free movement of air over the ground under their branches, the bordering of avenues, with rows of low-branched evergreens, is very apt to be carried to a dangerous extreme. I should by no means recommend the least interference with the beauty of suitable evergreen plantations; but it is unfortunately true of nearly all of the older places, that evergreens planted so closely as to produce an early effect have been left standing till they have, in a great measure, lost their characteristic beauty. As a rule, clumps of evergreens, if standing on *dry* ground, may generally be left undisturbed. The removal of a single one would destroy the beauty of the whole, and it becomes a question whether the whole, or none, should be cut away. Large plantations of those trees should at least be mutilated to the extent of removing their lower branches high enough to give a free sweep of air over the ground under them. Clumps of shrubbery too large, and too close for the ground under them, to be cleared of their leaves in the fall, had better be done away with, especially unless at a considerable distance from the house.

As a general principle, it may be stated, with reference to trees, that they interfere with the best sanitary conditions if they are so close, or so low-branched as to prevent the growth of grass beneath them—a modified exception being made in the case of evergreens.

To give specific directions for the removal of plantations, or individual trees, is a more delicate task than I care to undertake, and touches too nearly the sentimental side of most men, and of more women, to be in any case an agreeable one. I have indicated what I believe to be the sanitary requirements. Except where the ground is unduly wet, in a district so sparsely settled as that under consideration, any mischief caused by retaining dense plantations will be chiefly injurious to the proprietor, who is himself responsible for them.

Concerning ponds, I feel it more incumbent upon me to disregard the sentimental consideration. In the whole course of my examination I have seen very few of these ornamental appendages which I did not consider totally and absolutely bad, and I have not hesitated, even where they lie in the course of rapid streams, to recommend their remorseless destruction. I desire to make the same recommendation, with all the added emphasis of which I am capable, concerning filthy pools and fountain basins which have no such natural water supply.

Respectfully,

GEO. E. WARING, JR.

NEWPORT, R. I., Dec. 30th, 1878.

IRVINGTON SANITARY SURVEY,

BY

GEO. E. WARING, JR.

Consulting Engineer.

SECTION 1.

THE WILLSEA BROOK.

The first brook in the tract with the examination of which I have been charged (beginning at the South) is known as the "Willsea," or "Cortland Palmer" brook, which takes its rise in the woodland at the east end of Cyrus W. Field's property and in the property lying to the south of this. These sources being remote from habitations, and, as I believe, amply protected by forest growth, need not be considered here. The streams issuing from them, and their extension through the Cortland Palmer farm, through lands east of Broadway, and through the ravine bounding the estate of James Wilde, Jr., is, in my opinion, a very important factor in the problem with which we have to deal. I make no account of the character of the swampy lands in which these waters originate, for the reason that there is no evidence leading even to the presumption that streams flowing from marshes overgrown by forests have, by reason thereof, any specially pernicious effect on either the soil or the air. I am satisfied that we shall attain our end if we confine our attention to the brook and its branches after they begin to run through open ground.

The eastermost branch of this stream, after leaving the woodland at the east of the Cortland Palmer farm, flows

through a rough bushy pasture in a channel which is much obstructed by accumulated vegetation, by stones, and by other obstacles. It will be necessary to rectify the course of this stream, straightening it as far as possible, reducing its level so that its banks shall be at least three feet higher than its bed, giving it a permanent channel, and conducting directly to it by open ditches the water of the various small springs and swampy patches which appear in this field. This is all that will be necessary until we approach the pond connected with the slaughtering establishment of Loan Bros.

Without entering into a detailed argument as to the pernicious effect of animal fouling upon a stream that runs through so long a course past many residences, it will be sufficient to say that such fouling is absolutely inconsistent with the health requirements of the community; and I deem it of the first and utmost importance that this whole establishment be removed, and its site thoroughly purified. Were it possible to carry on the business without water—or without the escape of polluted water beyond the premises—it would, perhaps, be safe at least for some years to come, to permit it to continue. In fact, however, the considerable use of water, and the flowing away of polluted water are indispensable accompaniments of the industry. The whole condition at this point is unqualifiedly and dangerously bad, and I call the attention of the health authorities to this as one of the most important objects to which they can give their immediate attention.

I recommend that the slaughtering and rendering buildings be removed, or that they be devoted to some other and inoffensive use; that the dam forming the pond be opened for such a width and for such a depth that the bottom of the pond may not only be laid dry, but that it may be traversed by a straight water-course having its bed at least three feet below the level of the present deposit at the bottom of the pond—after this shall have settled by drainage. The method of the construction of this ditch

through the level ground, should be the same as that indicated for the swampy field east of Stymus's property. The spring south-east of this pond should be thoroughly drained by a deep ditch leading to the main channel above described. Below the line of the present dam an open ditch, at least three feet deep, should be substituted for the present covered one.

The swampy field lying north-west of the Loan Brothers' establishment is almost level throughout nearly its whole extent. It receives, near its north-east corner, the outlet of Cyrus W. Field's ponds, through a brook which needs attention at its northern end to a distance of five or ten feet north of Mr. Field's south boundary. The swamp is also fed by a stream flowing from the forest east of it, the course of which is not especially well defined from its point of entrance to its junction with the main brook. The present courses of the streams in this swamp need have no influence upon the final improvement. They are shallow, irregular, sluggish, obstructed and overgrown with bushes.

Beginning at the bridge in the south west corner of the field, where the road crosses the brook, and following up the stream for a distance of about 35 feet, we come to a low place which is suitable as a starting point for our work. From this point (east of the eastern bank of the brook) three straight ditches should diverge; one running in a north-easterly direction and striking the present brook, 150 feet south of Field's line; another running straight to the point where the present brook, from the forest to the east, and that from the Loan Brothers' pond come together to make the main brook; and a third, clearing the high lands at the south, and running straight to the present brook, about 250 feet below the Loan Brothers' dam. These new ditches should be made according to the instructions given for the ditches through the swampy field east of Stymus's property. The earth excavated in making them should be used, so far as needed, in filling up the present course of the brook through

the field, excepting the three branches leading to Field's ponds, to the forest to the east and to Loan Brothers' pond, and excepting the continuation of the old brook from the point of junction of the three ditches to its point of exit from the field. If more earth is excavated than will be required for this purpose, the remainder should be strewn over the field, or used to fill up its lower spots. Special care should be taken that none of it is suffered to remain along the side of the new channels, where frequent shallow gutters should be made to hasten the escape from the surface of the ground of its standing water. In various places, about the boundary of this swamp, there are springs and small marshy tracts which should be connected with one or other of the new ditches by straight and sufficiently deep ditches. This work being finished, the whole field should be absolutely cleared of all low growing shrubs, etc., wherever it was originally wet or marshy in its character.

The present bridge should be replaced by a securely built structure having an opening of not less than eight feet between its walls, and having its water-way formed in the same manner and on the same slope with the banks of the ditch from the swamp.

Below this bridge and as far as the swamp at the head of the pond near the Cortland Palmer farm house, the fall is considerable, the ground is irregular in its character, there are many stones obstructing the course of the brook, and no inconsiderable amount of rubbish, and in places it is overgrown with bushes. It is not advisable to attempt any straightening of the *general* course of this part of the brook, but its minor irregularities should all be removed, as should all stones and rocks which give sudden changes to its direction. Its bed should be paved on a section such as is shown at the bottom of the ditch, a cross-section of which is given in the diagram. Its banks should be sloped to an easy grade so far as rocks and stones will allow, and should be firmly sodded. All springs and

marshy places which find their natural outlet toward it, or whose waters may be led to it, should be connected with it by deep ditches. About 350 feet south-west of the bridge above referred to, and 100 feet north of the main course of the brook there is a considerable pond which should be emptied by a deep, straight, paved and sodded ditch leading to the brook through the lowest part of the land. On the hill 500 feet north of the brook and about 500 feet north-west of the pond just described, there is a marshy pond hole high up on the hill. This should be emptied by carrying out, through the slope of the hill, a ditch with broadly sloping sides deep enough to drain the deepest point of the pond. After this ditch comes out to the surface at the south it may be continued by a small gutter, as the amount of water flowing through it at any season will be inconsiderable. All of the bushes along the present line of the brook and near any spring or marshy spot near it, or along the course of the ditches by which these are to be drained, should be removed.

We come now to the field containing the pond which is near to the Cortland Palmer farm buildings. We have followed the course of the brook as far as the fence bounding this field on the east. From the point where the brook passes this fence a straight ditch should be dug as a new channel for it (paved and grass sloped as hereafter indicated), and leading directly to the point where the brook divides into two parts and follows two different channels through the marshy land at the head of the pond. From this point it should be continued, by as straight a course as the character of the ground will permit, to the point where the brook leaves the pond below the dam. That is to say, the pond should be abandoned and its present bed should be traversed by a paved and grass-sloped channel constructed as hereafter indicated. From the foot of the dam to the head of the former pond at the west side of the next fields the course of the brook should be treated in all respects as directed for that between the farm-yard pond and the

bridge at the edge of the swamp. The dam of this pond has already broken away and its bed has been left bare. It should be traversed by a channel laid on the straightest practicable course, and treated in all respects as above directed.

About the middle of this field the brook is entered by a branch leading from Field's pond, which runs through a deep ravine with a sufficient fall. The bottom of the valley has accumulated silt and rubbish until it is very marshy, and the stream is seriously obstructed. The line of the brook should be rectified; its bed should be carried to a depth of at least three feet below the present bed of the ravine, the bottom paved with stone and the banks grassed as directed below; and should have its banks, and the marshy ground through which it runs entirely cleared of bushes.

Below the old dam, above spoken of, it will only be necessary to straighten the course of the brook and regulate its character as far as the fence to bring us to what I regard as the second great defect of this part of our territory—the swampy field east of Stymus's property, which has for some years been overflowed in winter to make an ice pond. I believe the fouling of the waters of this brook, by the slaughtering and rendering establishment near its sources, to be dangerously bad—as a possible source of *zymotic* disease; but this large and aggravated marsh has doubtless more to do with the generation of fever and ague in this part of the village of Dobbs' Ferry than any other single district within its limits. Its influence upon the health of those residing on the high land north east of it (Messrs Stone, Lindley and Field) cannot, I think, fail to be pernicious. It is a large tract of ill-drained, and periodically flooded land, in the best possible condition to serve as an active source of malaria. Indeed, I know no spot in the whole territory which, regarded only with reference to fever and ague, I consider worse, and not many are so bad.

Although the southern portion of Stymus's land is considerably better in appearance, and somewhat better in reality, it seems evident that it is very far from being wholesome, and that the influence exerted upon it by his pond is decidedly bad. I propose to consider both tracts together.

The culvert under Broadway is sufficiently low to afford perfect drainage for the whole area; and we will take this as our starting point. It should be left to Mr. Stymus's discretion to regulate the borders of his present pond as he pleases, the wall being sound and good; it should be considered a matter of public interest that the pond itself be destroyed. To this end I recommend that the west wall of the pond be cut down for the whole width of the present overflow, to a level six inches higher than the floor of the culvert under Broadway at its eastern end; that the course of the brook between these two points be rectified as far as practicable; that its bottom be a stone-paved gutter, and that its banks be sloped substantially as directed for the main swamp.

A channel should be furnished for the brook from this dam to the junction with the main brook of the branch coming from the north, the same to be constructed as hereafter directed; the depth at its upper end to be four feet below the present surface of the swamp in that vicinity, and the grade between this end and the abandoned dam to be, as nearly as practicable, uniform.

The construction of the work from Broadway to this point—the present course of the brook in the swamp being followed—will be facilitated by temporarily damming back the three streams leading to it, and carrying their overflow around the outside of the present pond by shallow surface gutters.

From this point upward on the main brook, and on its southern branch, it will be better to abandon their present beds and strike out new courses through fresh land—better, because easier and cheaper, because work done in

new land will be sounder, and because the accumulation of silt by the natural process of overflow, and by the cleaning out of the bed of the brook, have raised its banks along its course considerably higher than the adjoining land.

In the accompanying diagram the double lines show the present courses of the brooks—not by actual measurement, but by careful sketching. The dotted lines indicate the direction that it is proposed to give to the new ditches. The dotted line 'A' shows the location of the ditch which is to take the place of the southern branch of the brook. The dotted line 'B' is a new ditch running through a low part of the field which it is necessary to drain. The double line 'CC' is the north branch, which should follow the present course of the brook. The dotted line 'DD' indicates the course of the ditch which is to serve as the main channel for the brook, from its point of entrance into the field to its best point of connection with the branch 'CC'; this course somewhat

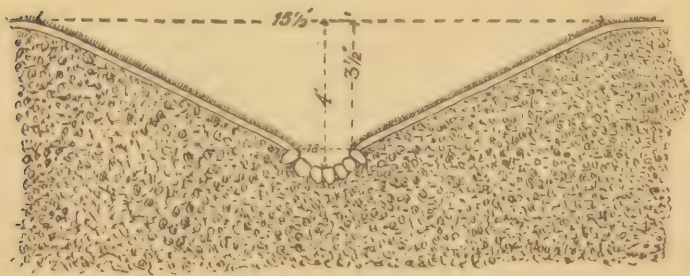


lengthens the line over which the waters of the main brook have to travel. But this is more than compensated for by the fact that it runs through lower land than the straight line, thus requiring less work, and that it obviates the necessity for making a separate drain through this land. It may be found advisable to allow this line 'DD' to follow the course of the old brook, for the upper 165 feet of its length. This is a question to be determined only by actual levels. Unless the saving of labor would be very material in following the line of the old brook, the new one is decidedly to be preferred.

The fall between the eastern boundary of the field and the point of junction may, if necessary, be very slight. It need not be more than three inches for the whole distance, though, of course, if more fall can be had it will be better to take it.

The north branch should be extended across the road leading to Stone's place, and to the well north of it—lowering the level of the water in this well. It should have deep branches extending east and west, along both sides of the road, as far as any indication of moisture is found at the bottom of the digging.

The manner of construction of these ditches is of much consequence: properly done it will practically be done for all time; improperly done it will give endless trouble, and however secure it may appear at the outset,



will, with a single year's neglect, tend to revert to the present unfortunate condition. The amount of water running through this brook at ordinary seasons is inconsiderable; I propose that it be provided for by furnishing a stone-paved gutter, eighteen inches wide and six inches deep, having a curved cross-section. The paving should be done with stones of nearly uniform size (or thickness), and they should be well bedded in clay and gravel, so as to reduce to the minimum the danger that the filling material will be washed out by the current. The smoother the water-way, the less the danger of such washing. With even tolerably good workmanship the amount of washing cannot be serious. In grading the bottom of the ditch to prepare for this paving, care should be taken to dig no lower than necessary, so that the stones may rest upon the unmoved earth, and be in no danger of being disturbed by the settlement of loose material under them. The center of this gutter should be, as nearly as a uniform grade will allow, four feet below the level of the ground at each side. From the edges of the gutter the banks should slope back on each side with a slope of two horizontal to one vertical. The extreme width at the top will be therefore, a little over one rod. The banks should be sloped to a true grade and should be sodded to the top, a sufficient proportion of the sods being pinned, especially the lower tier, to ensure their holding in place until they take root. In forming the slopes no point should be dug out beyond the desired grade, for any filling out to correct errors will be a source of weakness tending to cause a slip of the sodding. Constructed in this way, there will be no danger of the caving in of the banks; the slopes may be mown quite down to the gutter, affording ample security against the growth of bushes and rushes; and the ordinary flow of the brook will have a permanent and uniform channel through which to run. A great accession to the stream in time of freshet will be amply provided for by the grass-protected, valley-like channel above the gutter.

Whenever watering places are needed for cattle they should be provided by carrying out side bays. These may be large enough for several animals to stand in them, but their bottoms should be so paved as to prevent them from becoming tramped to a miry condition.

I submit this as the type that I recommend for all open ditch work wherever such may be necessary anywhere within the territory under consideration.

Experience has shown that a ditch thus constructed is much better than any ditch with stone walled sides.

Where it is not possible to give such a slope as is indicated to the banks, because of rocks, or stones, or high places through which the course passes, the banks should be made to conform as nearly as practicable to these directions, and the bed in all cases should have a paved channel.

The ditches indicated for the drainage of this land are all that seem to me imperatively necessary to bring it into a healthy condition. It would be improved, in a sanitary point of view, by thorough tile drainage, and the expense of such improvement would be a good agricultural investment. I do not, however, deem it so necessary on the score of health as to justify its being made compulsory upon the owners of the land.

The south branch of the brook coming in from behind the village of Dobbs' Ferry I have not followed further than the southern boundary of this field, because my instructions lead me no further. It is obvious from the general character of the valley to the south, that a simple extension of the same improvement would be productive of good results, and I should say that it is to be regarded as necessary to the health of houses near it.

After passing Broadway the character of the brook and its surroundings changes at once and materially. Throughout nearly its whole course from Broadway to the Hudson river, it passes through a deep, thickly-shaded and steeply-descending ravine, the bed of which seems

almost to be formed of boulders and blocks of stone which obstruct the course of the brook at almost every step. Fortunately, the fall is so rapid that a very slight rectification of the bottom will prevent any serious accumulation of rubbish which might dam back the stream ; and as the element of beauty is, after the health consideration, of the greatest importance in such a neighborhood as this, I am glad to feel satisfied that it is not necessary to give a smooth formal bed to the water-way throughout this part of its course. The only serious criticism that I have to make on this part of the brook is that its water-way is unnecessarily wide, and much ground not occupied by the actual stream is made wet by it. To obviate this the general course should be deepened at least one foot, the stone and earth taken out being thrown to each side and the rock channel being narrowed. This part of the work will require annual attention, for each heavy freshet running through such a ragged ravine will tend to restore the present condition of things.

Between Broadway and the Croton aqueduct there is a pond which ought to be abandoned ; the simple removal of its dam and the draining out of its accumulated deposits will be sufficient ; further down the stream there is a well-built wing-wall dam of solid masonry acting as a feeder for a water-ram ; the pond which it forms is very small, and I see no reason for its removal. Its annual clearing out is quite essential.

A short distance further down there was formerly a pond, of which the broken dam is under a bridge ; evidently this pond was entirely filled with silt, and since the breaking away of the dam the brook has cut a deep and wide channel through it ; the sides of this channel should be sloped and grassed, and its bottom should be stoned so as to prevent further washing as far as possible. Further down on the south side of the brook is a ram tank which leaks ; it should be made tight. Its present outlet is through a short piece of iron pipe, delivering into a

wooden trough, which leaks, and helps still more to moisten the ground in this part of the ravine, which is here of considerable width. The tank should be made tight, and its outlet should be carried by an iron pipe quite to the brook. Still further down is a dam, the pond of which is nearly filled with silt, from which water runs through an elevated wooden trough to a water wheel in a building some distance below. This pond being full, and the water flowing around the dam beyond what is needed to work the wheel, it is evident that efficiency of the power would be as great if a cask were sunk into the course of the brook and a tight iron water-conductor were led from it to the water-wheel, the pond being abandoned. This change would obviate the present serious objection, that the trough overflows and leaks and makes the land under it very wet. Above the water-wheel is a spring, which should be drained away. Still further down, at the edge of the flat and at the side of the main brook, there is a pond which is fed by a side branch of the stream; this pond has recently been cleared out and is in a tolerably good condition. If its regular cleansing can be insured I am not disposed to *insist* upon its being given up; but do very strenuously recommend that it be given up; and if I owned it, it certainly *should* be given up, as being a possible source of trouble, and a sure source of annoyance. If retained it should be subjected to frequent inspection by the sanitary authorities, and especial care taken that the land about it is not unduly moistened by filtration through its banks. The ravine debouches at the upper end of the meadow through which the brook flows, to escape under the railroad. I recommend that this part of the brook be made three feet deep, one foot wide at the bottom and ten feet wide at the top; and that it be well paved with stone at least half way up the banks, and sodded above that point.

From Broadway nearly to the river this is a deep and damp ravine, containing along the course of its stream

many serious accumulations of organic matter; it is absolutely hidden from the light of the summer sun; and even now, after the leaves have nearly disappeared and during the highest winds, there is very little circulation of air within it. In addition to this, the enormous mass of deciduous forest fills the ravine every year with its falling leaves, and adds constantly to the amount of decomposing organic matter with which we have to contend.

The absolute importance of sunlight and ventilation seems to me to make it imperative that a rigorous use of the axe be at once made along the whole of the ravine. There is no objection to leaving a few of the larger and finer trees at and near the top of the bank on the south side. But, with this exception, the whole of this bank should be entirely cleared, not only of its underbrush, but of nearly all its trees, so that the sun may fall directly upon the brook and upon the whole bed of the ravine. The north bank may be treated less cruelly; but even here I should advise that all of the underbrush and at least seven-eighths of the trees—all but the finest ones—be removed. It would be better that two trees should stand near enough together for their branches to touch. None should remain which have foliage low down on their stems; or these should be trimmed to the height of at least ten feet. There should be no rod of ground which is not at some time during the day reached by the rays of the sun. The clearing being done and the rubbish removed, the banks should be brought into grass which will, in time, give a not unpleasant substitute for the present thick leakage.

CONCLUSION.

This tract may be regarded as being, to a certain extent, typical of all the brook valleys in the territory under consideration.

The principles upon which I have given the foregoing recommendations are these:

First. That whatever water may escape from the water shed should be led directly and by the most unobstructed course all the way to the river, being nowhere held back in ponds, for the reason that these, by increasing the surface, increase the amount of evaporation, and leave less water to flow on through the lower part of the channel; that they accumulate silt, refuse, and organic rubbish, which accumulation is a probable resting place or generator of malaria; that such ponds are very often sources of dampness to the land about them by the simple raising of the water level, and of the lands below them by leakage and filtration through their dams; that their dams now and then give way, sending such a flood down the lower course of the stream as to tear up its bed and damage work done for its rectification; and that they invite a puddling and fouling of their shores by the cattle resorting to them in hot weather.

Second. To reduce the level of the water course so far below that of the surrounding land as to ensure a permanently dry condition of the land.

Third. To lead to the water-course all water of springs, and marshy spots, to which they be made to furnish an outlet.

Fourth. To remove all bushes, undergrowth, vines, and thick growing trees which may prevent the free access of sunlight and the free circulation of air wherever the land is or has been wet or marshy.

I have endeavored, so far as possible, to keep constantly in view the "landscape" requirements of the case, and I appreciate the charm and attractiveness of deeply-shaded dells, of occasional close plantations, and of ponds, water-falls, etc. In a country where malaria had not gained a foot-hold I should be disposed to leave these wild and secluded nooks untouched. But I believe that, in the case under consideration, health taking the pre-

cedence of rural beauty, it is a matter of absolute necessity to do away with much which it would otherwise be pleasant to retain. While recognizing that such radical changes of natural features will not always be received with favor, and while I do not myself regard them as trifling, I do believe that they are made absolutely necessary by the present sanitary condition of the three villages and the intervening country, as the same has been reported to me.

SECTION 2.

HAMILTON'S POND AND THE BROOK DISCHARG-
ING THROUGH THE BARNEY PLACE.

Having examined Hamilton's Pond in its best condition and in its worst, and having studied its relation to the houses nearest to it, or in the direction of the valley trending away from it, I do not modify the opinion expressed in my preliminary report. *As a source of malaria which may affect the present population of Irvington, I think it may be disregarded.*

On the other hand, it is to be disregarded only because of its situation, and of its surrounding forest. Were the forest to be removed, or were population to extend to its near vicinity, then it would undoubtedly take its place as the worst fresh-water source of disease in the whole district. In view of both of these changes as being possible, and for the further reason that a forbidden spot of ground is never a pleasant neighbor, the improvement of this pond is very desirable.

In my judgment, the method of improvement proposed—the enlargement of the pond—is not advisable. It would be an improvement, but it would not be a cure. The easiest, simplest, and most effective treatment would be to remove the dam, to deepen the outlet, and to drain the pond to the bottom—to turn it into dry and wholesome ground. This being done, it will be easy to deter-

mine the best manner of collecting and storing the water of the springs by which it is fed so as to furnish a greatly improved supply to those who now depend on it, or who may wish to depend on it in the future. Every condition favors this change, and its complete execution would solve the whole problem in a satisfactory manner.

One branch of the brook in question takes its rise in Hamilton's Pond, whence its fall for about 200 feet is rapid and unobstructed; thence for 250 to 300 feet it runs through nearly level land. Here, it is deep, its sides are stoned, and it is in tolerably good order. Thence, as far as the projection of the east line of Dibble's property it has a rapid fall over a ledgy bottom. As far as this point it may safely be left as it is. Beginning here, from 50 to 100 feet east of the flat, swampy land above the pond, in the main course of the brook on Hamilton's land, decided improvement becomes necessary. Indeed, I am of the opinion that there are very few tracts in the whole region under consideration which is more thoroughly bad than the course of this brook and its branches, from the point under consideration to the crossing of Broadway. Probably much of the difficulty which has been ascribed to the condition of Hamilton's Pond, is really due to this source. The little fall that existed from this point westward is mostly taken up with the dam forming the small pond in the main course of the brook. The land continues low and flat as far as the east end of Abbottsford village. The pond referred to should be destroyed, and the whole course of the brook for the distance above mentioned should be straightened—preferably, so as to pass through fresh ground. It should be constructed in the same manner, of the same depth, and with the same cross-section as prescribed for the brook through the marsh east of Stymus's property (the Wilsea brook), and illustrated in the sectional drawing published therewith. In its present condition, this tract is eminently bad from over-saturation, dense overgrowth, frequent shaded pools of stagnant water, and gen-

erally with the most favorable conditions for the fostering if not for the generation of malarial infection.

The brook being put in complete order, all springs and marshy tracts near it, or whose waters may lead to it, should be connected with it by deep ditches.

In Dibble's field, immediately south of that containing the pond referred to, there is a pond concerning which, if it were only possible to give it an adequate supply of water, there could be no serious objection. It is tolerably deep, is surrounded by quite a good stone wall, and has well-constructed inlets and outlet. From its present condition and appearance, I should say that its owner has done all in his power to make it unobjectionable. Unfortunately it lacks the essential element of a pond, in that it has no water supply. Even on the 21st day of November, it having rained hard the previous day and night, and considerably during the previous week, its inlets and outlet were quite dry and its bottom not nearly all covered. I think it may be accepted as a demonstrated fact that this condition of things is incompatible with the health requirements of a district which is not above the suspicion of malaria. The field in which this pond is situated is in as good order as shallow drains, some of stone and some of tiles, could make it. Had it been possible to make the drainage deeper, its condition would be all that could be desired. It has evidently been of a swampy character at some former time and its drainage is not now sufficient to remove all swampy indications. The land east of this field, quite up to the woods, needs draining.

In the next field south of this (Harrison's) there is another pond, similar in its general character to Dibble's, but with an even less efficient water supply, with much less careful attention, and with somewhat greater indications of unwholesomeness. It is surrounded by a fine growth of willows. I regard its retention as a pond quite inadmissible.

The amount of water flowing from this pond and through Dibble's field is too slight to interfere with the

proper execution of the work; and the ditch from each pond, as well as their continuation to the main stream under consideration, may properly follow the present course. These streams should be not less than three feet deep, where they leave the ponds, and they should follow as nearly a uniform grade as is practicable to where they intersect with the grade of the ditch which is to be substituted for the brook. The willow trees now growing about Harrison's pond may be left standing with advantage. Probably, an outlet will be secured for deeper drainage on parts of Dibble's field. The owner will doubtless see the advantage of such drainage from the agricultural point of view, and will be glad to execute it when a sufficiently deep outlet is provided.

On the north side of the brook, some distance above the pond first above referred to (on Hamilton's land), there enters a sluggish stream affording an outlet to Wendel's pond. I have given much consideration to this pond which certainly has elements of beauty that give it value. It lies quite at the head of its stream, and is free from several of the objections which obtain in the case of ponds in the course of running brooks. On the other hand, from the purely sanitary point of view, I regard it as dangerous. If fever and ague has occurred in Gregory's house, immediately north of this pond, I should say that all probabilities point to it as the source of the disease. The trees, by which it is surrounded, being large, not very numerous, and mostly with naked trunks, probably have no other bad effect than to fill it with leaves, of which it now has a goodly deposit in a more or less advanced stage of decomposition. The pond does not always remain filled to its high water mark, and the exposed edges consist largely of decaying vegetable matter. When full, its influence must be even worse than it now is upon the flatter lands about it and upon the lower lands south of it. I recommend that the brook running from this pond be reconstructed precisely as recommended

in other similar cases, and that its bottom be laid as nearly as practicable on the true grade between the bottom of the new main ditch into which it is to deliver, and a point three feet below the present level of the ground fifty feet south of the pond. The dam should be widely opened, and after the deposit has drained sufficiently to be worked, the ditch should be continued through it, terminating at a depth of two feet at the north end of the present swampy border which extends northward from the upper end of the pond. It is especially important to Mr. Gregory, if not to those living at a greater distance, that this exposure of the bottom of the pond be effected not later than the middle of February, that there may be thorough exposure to frost and rain before the opening of spring. As early as practicable the exposed and naked ground should be sown with grass seed and with oats, so that it may as soon as possible have the protection of vegetation.

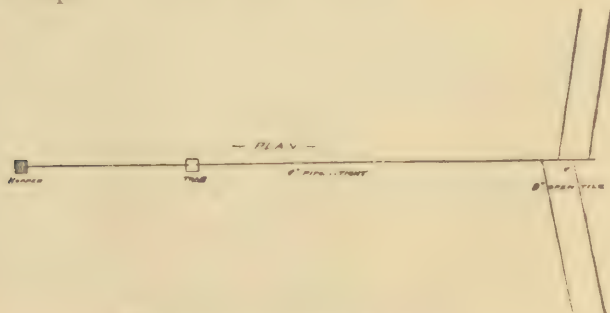
The brook from the point at which we left it, east of the village of Abbotsford to the crossing of Broadway, is simply an abomination, and its proper reformation implies something more than a mere physical amendment of its channel. It is here not only a brook, it is also a sewer, fouled with the refuse matters of a poor and mismanaged settlement, where pigs and poultry add their embarrassing complications to the question.

Precisely what is best to do with reference to this part of the subject it is not easy to determine. These people must live, and under the best circumstances their lives must be attended with the production of no inconsiderable amount of liquid filth, which cannot safely be kept in cesspools, be thrown upon the ground, be run into the brook, nor as now be disposed of by a combination of these three methods. To allow the present condition to continue would be fatal to anything like a complete sanitary reform of the neighborhood. Considering the character of the surrounding population, it is not unlikely that an indictment as a nuisance would hold against the settle-

ment. Yet it may not be for the interest of the community to solve the problem by its removal to another point where similar difficulties would arise to give trouble to other neighbors. If any system of sewerage is to be adopted for the houses which might naturally be drained through this valley, the village of Abbotsford certainly should be included in it. Assuming that no such system of sewerage is likely soon to be supplied, I recommend that the keeping of pigs be prohibited; that the keeping of poultry be properly restricted; that the health authorities give especial attention to the arrangement of stables, and to the disposal of manure in such a manner as to prevent the escape of liquid from it; that the use of dry-ash closets or earth closets be compulsory, and that proper means be supplied for the disposal of the liquid waste of the households by a system of sub-irrigation pipes, constructed on the same principle with that connected with Cyrus W. Field's house. For the small amount of water used in these households this arrangement may be

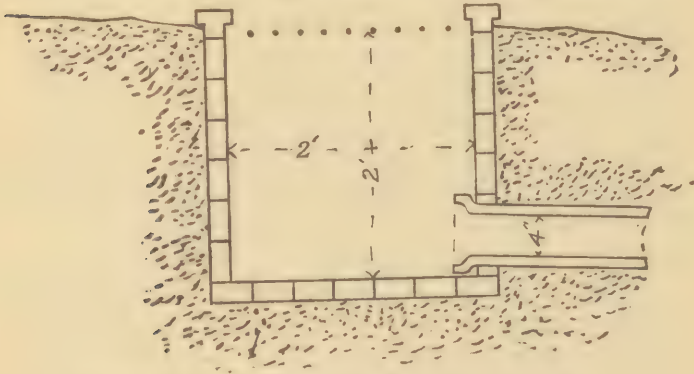


Vertical Section showing arrangement of Hopper, Grease-Trap and Main Drain. extremely simple and inexpensive. A vertical section and plan are given herewith. Also diagrams showing the manner of constructing the receiving hopper and the grease trap.

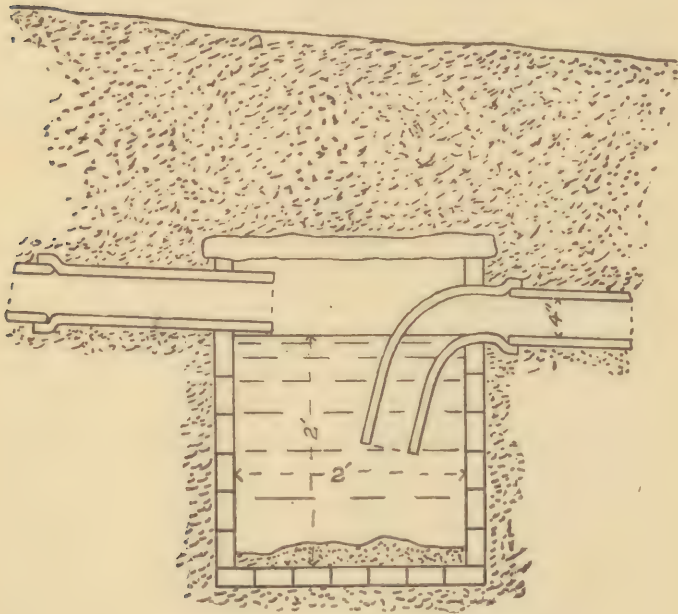


Plan, showing arrangement of Drains.

The one all-important thing is to prevent organic matter from reaching the brook, either directly, or in solution or admixture in the water flowing to it from the sur-



Hopper, flush with surface of ground, for throwing down slops.



Grease-Trap, for retaining scum and deposit.

face of the ground. The land drains should be drains for the removal of soil-water and rain-water only. All fouled liquid of every sort should be disposed of by the sub-irrigation system.

The hopper and grease-trap, indicated in the course of the main drain are to be built in the ground in such a manner as not to be disturbed by frost. The principle of their construction is shown in the foregoing illustrations.

The main drain should be of 4 inch vitrified pipes with well cemented joints. The laterals should be of 2 inch red tiles *with open joints*. These latter should be not more than 12 inches below the surface of the ground.

Under the best circumstances it will require no slight exercise of authority to prevent the casting of dirty water upon the ground. According to the completeness with which this is effected will the system to a great degree be successful or unsuccessful. This source of fouling being removed, the channel of the brook should be continued around and past this settlement and as far as Broadway through a ditch, as nearly as practicable, four feet deep, with paved gutter and grassed slopes as directed in other similar cases. Between Abbotsford and Broadway the trees should be entirely removed from the low tract through which the brook passes: the brook should be straightened, and the spring between it and Broadway should be drained into it.

From the Broadway culvert, down through Wendel's land, the brook has a good fall, but is too much obstructed by the tumbling in of its stone walls. It should be deepened to at least three feet below the level of its present banks, and, so far as it is not necessary to wall its sides in order to dispose of the stones now used for that purpose, it would be better to construct it with sloped and sodded banks. In any case, whether the banks are sloped and sodded or laid with stone, the channel of the brook should be well paved in the same manner and with the same section as shown in the illustration referred to above.

Entering Drake's land, the brook, although its fall continues rapid, is obstructed to an increased extent by loose stones, by the caving in of its banks, and by the growth of alders and bushes, and it is too much shaded. Its bed should be lowered to the depth of three feet below the level of its present banks, its course should be straightened, all bushes, undergrowth, and weeds should be cleared away, and only large and desirable trees should be left standing, preferably not to exceed one half of the present number. It now runs through a somewhat damp valley which should be opened to the sun and wind as much as possible. Whether its banks should be sloped and sodded, or laid with stone, should be determined by the quantity of stone to be got rid of, by the character of the ground, and by the question of cost. In either case its bottom should be a paved gutter, as recommended for the brook passing through Wendel's land.

At Drake's north line, the brook enters a culvert which debouches at the north side of Barney's entrance road. This culvert seems to perform its office satisfactorily, and it is only necessary to ensure its doing so for the future.

Shortly after leaving the culvert, the brook unites with an important branch coming in from the eastward, which furnishes an outlet for sundry swamps, springs, and small streams some distance east from Broadway, and on both sides of the road leading to Saw Mill river valley. The principal southerly branch of this stream runs for nearly its whole length through the land of Charles Harriman. In the deep valley which is spanned by Harriman's bridge, and above this, the brook need not claim our attention. From the foot of the valley it should be deepened to at least three feet, and, although I do not prescribe it, I recommend that it be grass sloped and paved as above directed. Its bottom should be not less than three feet below the general level of the ground through which it passes. The drainage operations now in progress upon

this nearly level stretch of land will, in all probability, in connection with the rectification of the brook as above, be all that is necessary to remove any objections which may now exist in connection with this tract. On Harriman's land near the Saw Mill river road, there is a spring which is now led to the main brook. It is only necessary to secure the permanent good condition of the channel by which it is so led.

The field opposite Harriman's, north of the Saw Mill river road, is very largely occupied by a thoroughly bad and unwholesome swamp, bounded on two sides by two branches of the brook. Two straight ditches following nearly the general course of these two brooks should be substituted for them; these should be four feet deep, and constructed in all respects as directed for those in the field east of Stymus's. (See Wilsea Brook.) It is probable that these two ditches and a connecting ditch running at the foot of the highland along the north part of the east boundary of the field, so as to cut off the water coming from the hill, will be sufficient to put the land in a satisfactory *sanitary* condition. On the score of health it *may* be necessary, and on the score of economy it certainly will be advisable, to make one or more intermediate ditches for the more thorough drying of the land, or, which would be still better, to give thorough tile-drainage to the whole of the area included within the ditches above described. The main ditches being completed, all present runnels leading toward the swamp, and all springs and marshy patches which may be led to it should be connected by deep ditches, and by the most direct course with one or other of the main ditches. The earth removed in digging the ditches should be used for filling up the present channels of the brooks, so far as needed for that purpose. Any excess should be strewn over the surface of the swamp, or used to fill up its lower spots.

Both of these brooks are now much overgrown and obstructed. They are simply swamp brooks, bad in

themselves, and bad in their effect upon the adjoining land. The whole of the swamp, both banks of the brooks, and any land in this field which is now at all marshy or even unduly wet, should be thoroughly cleared of all bushes and undergrowth, —occasional large trees being in no respect objectionable.

From the point where the two brooks come together, to the road, as well as on the short run of the brook on Harriman's land, the same general system heretofore indicated should be followed.

After the brook returns to Adams' land, it has for a certain distance a sufficiently rapid fall. But its banks are much overgrown, and its channel obstructed and interrupted. Its banks should be thoroughly cleared of all growth save large trees—its channel being cleared so far as the rocks will allow.

A short distance below, there is a combination of artificial pond and swamp which, in view of its situation between Gregory's and Adams' houses, and of the relation it bears to Guiteau's, Wood's, and Richards's houses, is to be regarded as especially objectionable. The pond should be abandoned, the course of the brook should be straightened, and, so far as possible, its new channel should be constructed precisely as directed above in all cases where level land is passed. All springs and marshy places, especially two springs at the edge of the road, all ponds of water, and all runnels from the hill, should be led to it by sufficiently deep ditches. All undergrowth and bushes should be removed, and all land which is now at any season of the year marshy or unduly wet should be thoroughly exposed to the rays of the sun.

In the extreme northwestern corner of Gregory's land, where there runs a short stretch of this brook, its bed and banks should be treated as above directed, and especially the rank growth of weeds and bushes now encumbering this part of the ground should be entirely removed.

Passing to the land of Mrs. Scott, we find a pond

which it would be much better to abandon entirely. In its present condition it is decidedly objectionable. The same is true, though to a less degree, because of its smaller size, of the pond in the north-west corner of Mrs. Scott's property; there is no justifying reason for its retention. The course of the stream between these two ponds should be rectified, and should be continued as above prescribed through the two ponds.

On the Harriman place, at the corner of Broadway, the brook is in tolerably good condition, save where its water is held back by a dam near the house. It is decidedly to be recommended that this dam be removed, and that the brook throughout its whole course have a depth of at least three feet, with paved gutter for its bed, and sodded slopes for its banks.*

West of Broadway the brook crosses the land of D. N. Barney through a channel which, while it has a sufficient fall, is too irregular as to its banks, and too much overgrown. I recommend that its minor irregularities of direction be rectified; that its bed be made three, and preferably four, feet lower than the level of the adjoining land—its bed being a paved gutter—and that its banks be sodded slopes, as above.

All of the trees growing in this valley should be removed, and the wood on the hill side north of it should be thinned out and entirely cleared of underbrush.

A short distance below the aqueduct there is a dam which backs up the water into the mouth of the culvert. This dam should be entirely removed, and the brook should run in a deep ditch of the prescribed form and character. If the raising of this water is necessary for the working of a ram or water wheel, the same purpose can be attained by sinking a cask in the course of the stream and carrying its water through an iron pipe. In my opinion there are too many trees, and there is far too

*The depth at the lower part of the lot must, of course, be regulated by the depth of the culvert under Broadway.

much small growth along the whole course of the stream as far as the fence, near which it crosses the private road. Especially is this the case on the south side of the brook and toward its lower end, though as far as this fence, clearing seems to be necessary on both sides of the road.

Through the field north of the road the course of the brook is crooked, and it is much obstructed with stones and rubbish. Through its northward course there are too many trees near it. These should be so thinned out as to admit sufficient sunlight and circulation. The banks are high and dry, but they should be sloped and sodded, and the bed should be paved in accordance with the plan elsewhere indicated. The brook itself requires the same treatment all the way down to the point where it diverges—one branch entering the pond and another passing around to the north of it. In the field south of the brook and east of A. H. Barney's stable, there is a wet tract which can best be drained by carrying an outlet drain of two inch tile along the south side of the brook and delivering into it below the present dam, or, much better, this dam may be removed and the brook deepened near this stable. The wash of A. H. Barney's stable yard should be prevented from reaching the brook, especially if his pond is to be retained. Near the stables there is a considerable amount of underbrush and rubbishy growth which should be cleared away. From A. H. Barney's stable to D. N. Barney's stable the brook is too much shaded by trees.

It is not easy to determine what course should be recommended with regard to the large pond on A. H. Barney's place. As it stands, it is at least two feet too high; at its upper end it is filled with an accumulation of silt, and unquestionably its whole bed contains much decaying vegetable matter. I believe it to be thoroughly bad, but if it is a sufficiently important object to retain it, this may perhaps be done if the dam is permanently lowered two feet; if the depth of the water even in dry seasons is

made fully three feet in every part of the pond ; and, if every winter, the pond is emptied and thoroughly cleansed of all its accumulations. This cleansing is, in my opinion, of sufficient importance to the adjoining houses of the village, to say nothing of those on the Barney property, to make it incumbent upon the Health authorities to ensure this annual cleansing by actual inspection. It is extremely desirable that the pond be entirely abandoned and that the valley of which it now forms a part receive some other landscape treatment which will compensate for the loss of its present very decided beauty.

The course of the brook which runs north of the pond and which, the pond being removed, should carry all its water, requires the same general treatment prescribed for the upper portions of the stream. After it has been deepened, its bed paved and its banks completed, the low spots and springs near it should be drained into it, and all lands in its vicinity and near the pond should be made thoroughly dry and sound.

At least one half of the trees, preferably more, and *all undergrowth* between the present dam of the pond and the last bridge, near the gate opening to Irvington, should be removed. Below the bridge the course of the brook is now in perfectly good condition.

The changes above indicated being made, I believe that the whole region traversed by this brook and its branches will be unobjectionable. This is now very far from being the case.

SECTION 3.

SUNNYSIDE BROOK.

This brook takes its rise in swamps some distance beyond the settlement known as "East Irvington." Its course in the neighborhood of this village is through low, flat land, some of it swampy in its character and some of it fouled with sewage matters from a house. This part of the brook, however, need not be especially considered here, as it is beyond the line of the village, and, in my opinion, not bad in its influence—except upon this settlement, which is not now under consideration.

For the purposes of this report it will suffice to begin the first examination of the stream at the culvert under Morgan's entrance-road. Immediately below this culvert the land is wet and marshy; the marsh occupying an area of about one and a half acres on the south side of the brook. Its borders are defined at the east and at the west by sluggish streams of which the western one takes its rise in an obvious spring. North of the brook, and, except at its end, at a little distance from it, there is another marshy tract. About 250 feet below the junction of this tract with the brook, and below the western side of the swamp at the south, the brook takes a somewhat rapid fall over a mass of rocks which are overgrown with a thick growth. This growth should be cleared out, at least, so as to remove its underbrush and its smaller trees. At this point the rocks should be removed so as to increase the depth of the brook three feet.

From this point to the culvert under Morgan's road and on as nearly a straight line as is practicable, a new ditch, of the prescribed form and arrangement, should be constructed to take the place of the present brook. This being done, the two swampy tracts above spoken of, as well as the stony, wet tract below them, should be drained into the brook by sufficiently deep ditches to remove all standing water, and all extraneous water coming from higher land in their vicinity. Below the point at which it is recommended to deepen the brook, and as far as the small dam at the north-east corner of Cunningham's field, the brook has, in the main, a sufficient fall, and, considering its location, the volume of water flowing through it, and the character of the land adjoining it, it will be sufficient to remove its occasional obstructions, such as stones, bushes, etc., to rectify its minor irregularities as much as possible, and to clear its banks of all bushes and rank weeds.

At the north side of the brook there enters a stream leading from a pond and spring house in the woods north of the road. There are several wet places in this wood, and an inconsiderable amount of underbrush which might with advantage be cleared away. But, considering the amount of forest growth, none of this work need be insisted upon, as the trees will doubtless afford a sufficient protection to districts lying remote from it. The stream which feeds this pond drains a considerable marshy tract some distance northward from it. This tract is behind the hill which forms the natural boundary of our district, and need not be considered unless in the interest of the Bierstadt and Halstead houses. If the inmates of these houses are affected by malaria, the marshy tract spoken of is its most probable origin. If they are not so affected, this need not be considered.

The small dam spoken of is of no material consequence. But about it, and for some distance below, there is a considerable amount of close growth which should be removed. About 200 feet after entering Cunningham's field,

the brook becomes quite level, its water being held back by the dam near Cunningham's entrance. This pond is evidently of considerable importance and there is no material objection to its being retained, with the understanding that all land bordering it, and bordering the brook above it, which is not at least two feet above the level of the water, be excavated to the depth of three feet below its level. This depth of three feet should be insisted upon throughout the whole area covered by the retained water, and the banks should, in all cases, from this prescribed level of the bottom to the top of the bank have a slope at least as steep as one vertical to two horizontal. The work would be very much simplified and cheapened, and possibly the same advantage would accrue, if the dam were lowered one or two feet, the same conditions as to height of bank and depth of bottom being preserved as above indicated. If there is rock at the bottom of the pond this need not be disturbed; but there should be no *earth* bottom nearer than three feet from the surface of the water. The annual cleansing of the pond of all silt and vegetable matter should be assured.

Through Parish's place the brook has a rapid and almost constant fall, save where it is held back by three dams forming very small ponds. With proper care in the way of annual cleaning out, these ponds are too slight to be interfered with; but their cleansing is of imperative necessity. The brook flows generally over rock and among boulders, and is subject to obstructions by the irregularity of its course and by the accumulation of leaves and other rubbish. These obstructions should be obviated so far as possible; but it would be useless to attempt any such amendment and regulation of the bed of the stream as is prescribed in other cases.

The ravine through which it runs is much too densely shaded and there is too little opportunity for the circulation of air. The more completely its smaller trees can be removed, and the more efficiently the whole ravine can be

opened to the sunlight and to the free circulation of air, the better. The only spot along this course of the brook which is open to suspicion is the small low area near the corner of Broadway and the Sunnyside road. Here is a small, flat piece with the brook running on both sides of it, which should be as efficiently drained as the level of the culvert under Broadway will permit. All springs and wet places throughout the whole length of the ravine should be drained, all sand bars removed from the ponds and elsewhere, and the channel over the ledges and among the boulders should be so arranged as to retain as little rubbish as possible. This being done, and precaution taken against the filling of the ravine with leaves—by removing the excessive timber and by attention during the autumn—this part of the brook may be considered unobjectionable. West of Broadway the brook is so rapid in its fall and has so much rock and so very many large boulders along its course, that it is of no special importance to apply to it the rectification recommended in the case of the Barney brook: nor would it be possible, with reasonable cost, to secure this. Directions concerning its improvement, so far as the water-course is concerned, may be condensed into this statement—that it should have as free and constant a channel, and offer as little occasion for the accumulation of sticks, leaves, etc., as possible. In those exceptional cases, where its bed is too wide and where the ravine is made too wet by the stream, it will be necessary, even at the expense of cutting through the ledge, to lower its channel sufficiently to draw its water away from the sides of the ravine. For pretty nearly its whole course, as far as the edge of the flat, it is very much too densely shaded: and although there is less undergrowth than along some other streams, there is far too much forest growth, and trees sufficiently near the brook to cast their shadow upon it, should be rigorously removed to such an extent that no part of its course may be open to even the suspicion of *dankness*. The clearing thus recommended will be much less

detrimental to the beauty of the valley than might be feared, there being very many fine specimens of trees to be left, whose beauty, when fully exposed, will well compensate for the present shaded condition.

Jaffray's upper pond, above the aqueduct, in its present condition is (Nov. 15,) unquestionably bad. Close to the dam it has a sufficient depth of water, but its upper end is very shallow, being apparently filled with silt. A pond of this size, in the course of a stream of this character, must inevitably accumulate a considerable amount of silt annually; and in a ravine shaded even to the extent that this will be even after the clearing has been finished is quite sure to receive a large annual contribution of leaves. I see no way in which it can be made entirely unobjectionable except by opening its dam to the bottom and restoring the original character of the brook. By lowering its level one foot, and by excavating its whole bottom to the rock, or to a depth of three feet below the surface of the water, its character would be very much mitigated; but even then the objections to it would, in my opinion, outweigh any benefit to be derived from it.

The double pond at the lower end of Jaffray's place is open to all the objections of the larger one, and the beds of both these are now badly silted up and fouled with organic matter. It seems to me important that its two dams be removed, its accumulated silt and organic matter cleared out, and the brook restored to its natural condition. It is not my province to express an opinion as to the beauty of ponds of this character; I am considering them simply from the sanitary point of view; and it seems to me that in this regard the weight of argument is entirely against their retention.

On the Irving property, the brook after crossing the Sunnyside road runs northeasterly to the base of the hill and then turns sharply around toward the southwest, enclosing an open low space, a part of which seems to have

been arranged to serve as an ice pond. It would be better to carry the brook through the present ice pond by lowering the crest of the ledge four feet to furnish efficient drainage. With a view to possible springs coming out from the high hill to the north, the old channel of the brook should be kept open for their removal. After crossing the Sunnyside road and re-entering Fargo's place, there is a level stretch about 100 feet long which is insufficiently drained. The brook should be lowered at least one foot, and if this does not remove the surplus water a drain should be laid along the northern border of the tract delivering into the brook at its lower end. From here to the edge of the bay which is enclosed by the railroad, the clearing out of the forest growth is the only improvement needed.

The continuation of the brook through the flat will be considered in connection with the recommendation for the improvement of the river front.

SECTION 4.

TIFFANY-MATTHIESSEN BROOK.

This is a continuation of a stream on Williams' land which there runs for a considerable distance through a 12-inch pipe, and then through a culvert which discharges about 25 feet west of Broadway. At the immediate point of exit there is a duck pool which needs attention.

From this point to the culvert under the Aqueduct, the brook has, except for the last 100 feet, a sufficiently active fall but is considerably obstructed with loose stones and an accumulation of leaves. After the brook crosses the boundary between Tiffany and Matthiessen, it passes by a shallow ditch through wet land which continues down to the Aqueduct. In this land there is a spring on the same level with the brook. The culvert lies at a sufficiently low level, and this part of the stream should be lowered to the depth of four feet below the general level of its banks, its bottom being a paved gutter, and its banks sloped and sodded. Should this not be sufficient to remove the sources of moisture from the adjoining land, a header drain of broken stone or tiles should be constructed along the outer edge of the wet portion.

After crossing the Aqueduct, this brook runs through a very large stone walled channel, which is covered for about 135 feet of its length. The covering is in bad condition, the timbers supporting it having in places rotted away, so that the roof has fallen in and made more or less

deposit in the channel. The depression, through which it flows seems to be in a good and wholesome condition, and the *natural* course of the stream, all the way to the river, is uniformly sufficiently rapid. A little distance below the mouth of the covered conduit there is a small dam which I recommend removing. The accumulation of muck and decayed leaves should be cleared out, and this part of the course should receive the same treatment recommended for the rest of it. From the point below this, where it enters Matthiessen's land, to the dam under the drive-way, the brook is almost without fall: its bed is six feet wide, partly covered, in dry times, with only a thin film of water, which is in hot weather more or less foul from stagnation. The surface of its water is only 12 or 15 inches below the level of the ground on each side, most of which is decidedly and dangerously damp.

At the time the examination was made, the amount of water flowing over the dam might have been carried by a half inch pipe. As the fall at this point is about nine feet, it is only necessary to remove all loose material and lower the dam to secure the necessary depth for perfect drainage. Below here, the brook accumulates a considerable deposit of leaves, which, at the time of examination, was sufficient entirely to hide the water. The land to the north of the brook, between the two roads, is quite wet and should be drained. This land now is on about the same level with the *bed* of the brook. After crossing the road the brook continues on around the south side of an artificial pond—artificial to the last degree—which is supplied by a wooden spout bridging the brook, and conveying the water of the spring on south side of it. I believe that the retention of this pond is incompatible with a healthy condition, and I recommend that it be entirely abandoned, the land being restored to its original condition, or as nearly so as may be done by leveling the banks and dam by which the pond is formed. Several consider-

able springs flow into this pond, or rise from its bottom. These should be drained away through the general trend of the valley, striking the brook at a convenient point. Probably they could all be collected in a cask, at a sufficient height to work a ram; perhaps less efficiently than it may be worked by the present pond, but the fall seems ample to give a satisfactory result. The land immediately around this pond is now very wet and objectionable, but the simple act of restoring its original condition and draining its bed where necessary will be all that is needed, so far as the ground is concerned. It seems to me to be much too closely shut in by trees, and I recommend that at least every alternate evergreen forming the circle about it be taken away, and that the grove to the north of it, behind this row of evergreens, be considerably thinned out and thoroughly cleared up.

A short distance below, the brook flows through a covered channel under Tiffany's cow yard. It is to be recommended that especial care be taken to keep the wash of the yard from running into the brook. After leaving this culvert, the brook soon enters Tiffany's pond. At the time of the examination, the water at the upper end of this pond was only one foot deep, and vegetation growing upon it reached the surface of the water. Considerable patches of thick green scum were floating on the water at several points. It would be practicable to retain this pond, if thought very desirable, but, in that case, its upper portion, and, indeed, all its edges should be excavated to a considerable greater depth, and it should be extended toward the south to a good depth, quite to the foot of the steep hill. That part of the bank, which is now only eight or ten inches above the surface of the water, being cut away. Farther down its course the brook receives house sewage through a six-inch vitrified pipe. Some of this sewage matter makes an obvious deposit farther down the stream. From this point to the flat, the fall is very much less than above.

Throughout nearly the whole course of this brook, from the Aqueduct to the flat, the banks are sufficiently high, save where the water is held back by dams, which should be removed. The fall is sufficiently rapid to give a cleansing flow, even when the stream is small, were it not for the fact that its bed is very much broken up and obstructed by a confusion of boulders, drift-wood, etc. I advise that every dam in the course of the stream from the Aqueduct to the river, save, if insisted upon, that of Tiffany's pond, be removed; that the boulders and rubbish be entirely cleared out from its bed, and that it be given a smoothly-paved concave gutter at a depth of at least three feet below the immediate banks. Owing to the character of these banks, it will, as a rule, be easier and cheaper to protect them with stone walls than with sodded slopes, though in exceptional places the latter are to be preferred. Much of the lower course of the stream is through a thickly shaded deep ravine. From the sides of this ravine, and from the land adjoining the brook higher up the stream, all underbrush should be cleared away, and, preferably, all but the finer trees should be removed; certainly enough of them to admit of the free circulation of air and a sufficient admission of sunlight to the brook and its vicinity throughout the whole of its lower course. There are other springs than those mentioned above, and there are small tracts of land near the course of the brook which should be thoroughly drained.

If the brook can be reduced to the level indicated, and furnished with a uniform and easily scoured bed; if the trees and bushes are sufficiently cleared away; and if all springs and wet places are adequately drained, no fear of malaria arising from this source need be longer apprehended.

SECTION 5.

SHELDON BROOK.

The main stem of this brook takes its rise in the Sheldon swamp some distance east of Broadway. It need not claim our attention till it approaches Chestnut avenue. Just above this point its bed is too wide and wet. This difficulty may be removed by straightening and deepening the course of the brook, throwing the main stream through the depression now followed by a minor branch of it.

After the brook crosses Chestnut avenue, it runs along the foot of the hill which rises to the west. The land on that side is mainly sufficiently dry, but for a length of about one hundred feet and a width of about twenty feet, it is very wet. Farther to the south a depressed piece is made unduly wet by the water of a spring; about fifty feet to the east, between the brook and the west line of Chestnut avenue, the land is low, very wet, and overgrown with alders. Chestnut avenue seems at this point to have been constructed across an area of wet land and the condition existing between the brook and the west line of the avenue is repeated in a tract about three hundred feet long and fifty feet or more wide, east of the avenue. All of this area may be easily drained by a sufficient deepening of the brook, and by the digging of such deep ditches as may be needed to lead all of the water of springs and marshy tracts to it. This will probably require the deepening of the culvert under Chestnut

avenue. The bed of the stream should here be paved with stone, as described in previous sections, and its banks should be properly sloped and sodded.

From this point past Redfield's barns, and on to within fifty feet of the culvert under the Croton Aqueduct, the brook should be so deepened that its bed shall be at least three feet lower than the level of its immediate banks, or as nearly so as the grade of the culvert under the aqueduct will permit. The course of this part of the brook is tortuous, and it is very much obstructed and overgrown with alders. These should be removed not only from its banks, but from all wet lands in its vicinity. Below the line of Redfield's barns, on the other side of Chestnut avenue, there is some decidedly wet land, the water of which flows across the avenue. This should be drained into the brook by sufficiently deep ditches. The brook itself should here be regulated as to its banks and its bed as prescribed for other similar cases.

After passing the Croton Aqueduct, the brook enters a large pond on Clark's property, which is formed by a long embankment and a stretch of mason work closing in the mouth of a shallow valley. The pond is too large for the ordinary dry-weather flow to keep it in a thoroughly fresh condition. It is much too shallow about its edges. Part of its natural bank on the south-east side is so low and level that a considerable area is saturated. The artificial barrier forming the dam is inadequate to its work. The leakage through it forms a swampy tract, extending for several hundred feet along the north side of Sheldon avenue, and in places about seventy-five feet wide. The chief useful purpose of this pond seems to be to supply water to two rams located a little below it. Concerning its value as an object of beauty I have no occasion to express an opinion; but it seems to me that any consideration of this character is greatly outweighed by the fact that it serves to create a good deal of wet land below it, that it is at the worst season of the year more or less stag-

nant, and that it offers a large surface for the evaporation of water which properly belongs to the lower stretch of the brook. I advise that the pond be entirely abandoned, its mason-work dam being removed, and that the rains to which it now furnishes water, be supplied through a pipe leading from a cask or small reservoir located at the western end of the culvert under the Aqueduct. The pond being destroyed, the brook should be carried on the straightest course practicable from the culvert under the Aqueduct to the culvert under Sheldon avenue. It should be, so far as practicable, three feet or more below the level of the land, as this is to remain after the emptying of the pond. Its bed should be paved and its sides sloped and grassed as prescribed.

South of Sheldon avenue, the brook flows in a channel with carefully-protected banks, through the settlement known as Penny Bridge. It seems to be fated, no matter how well a country may be improved, that any considerable tract of low swampy land within it shall be occupied by laboring people and persons in poor circumstances who depend for their livelihood upon the serving of their more fortunate neighbors, and who need domiciles within easy reach of them. This is eminently a district of such character. All that was said in a preceding section of this Report concerning the village of Abbottsford applies with redoubled force, because of the larger population and the wetter land, to Penny Bridge. One would be justified in using vigorous language to describe its sanitary condition. It lies directly in view of all who pass up and down Broadway, and those interested in such matters may penetrate its hidden and filthy and saturated recesses and examine it for themselves. It is not worse than hundreds of other villages of its class, but it is not a proper place for human habitation; nor is it a worthy neighbor of the estates by which it is surrounded. It must contain more of the elements of possible infection than any other spot in the district under consideration.

It has been suggested that its worst features might be removed by raising the level of its streets and of its house lots. This would be a costly operation. The only purpose to be accomplished by filling in the ground, would be to increase the difference of level between the surface and the line of saturation in the soil; this may be quite as effectually accomplished, and much more cheaply, by leaving the surface as it is, and lowering the level of the water in the soil.

It is not only the immediate surroundings of the houses of Penny Bridge that need amelioration, but equally so a wide stretch of wet and often swampy land reaching on to Gurnee's property, quite back to the Croton Aqueduct. This land is sure, sooner or later, if left in its present condition, to be taken up by a population similar to that now forming the village in question, and any increase of such population, living under such conditions, is quite sure to be a menace to the health of the community.

The improvement undertaken here should be quite radical. In my opinion, the level of the brook through the whole village and the culvert under Broadway, should be reduced fully three feet below the present grade, a depth which may be secured by the requisite deepening of the brook west of Broadway. The brook throughout its whole course, from the north side of Sheldon avenue to Broadway, should run through a paved channel, not more than three feet wide and not less than one foot deep, of circular section. It should nowhere be a covered culvert, but always open to the air. Owing to the depth at which this channel must be placed below the surface of the ground, and to the fact that much of the land through which it passes, is occupied by small house lots, it will be better, for economy of space, to use walled banks than sloped and sodded banks; but these should be so constructed, that their permanence may be secured. In a brook of this character any considerable caving in of the sides, might, in a time of freshet, lead to serious injury to

other parts of the construction. The brook now runs southerly from Sheldon avenue, for the depth of a house lot, and then turns to the westward. It would bring it too near the house to straighten its course from the culvert to the old channel of the brook; but this sharp corner should by all means be made more gradual, the turn being made on a curve with a radius of not less than fifty feet.

The work of deepening the brook, as above recommended, is hardly more than a means to an end; for the brook in itself, except for its great width, is now in tolerable condition. The purpose of deepening it is to afford a sufficiently low out-fall for the drainage of the house lots of the village itself, and of the low Gurnee meadow. This latter, in its present condition, can hardly fail to be an active agent in the fostering, if not in the generation, of malaria. The same motive, or the same authority, which would direct the improvement of the brook should be made to include the sufficient drainage of these neighboring lands. It is probably not necessary for sanitary reasons alone that any regular system of tile drainage be resorted to, but it is important that the wet land, south and east of the village, be furnished with sufficient deep and properly-constructed ditches, to secure the permanent removal of its surplus water, and that all the evident sources of water from the highlands lying about it, including, of course, the culvert under the Aqueduct be led to it by such means as shall remain permanent and efficient without frequent attention. There are indications in the ditches and the tile drains on the Gurnee land, that an effort has, at some previous time, been made to bring it into good condition; but, partly owing to the lack of a sufficiently deep outlet, and partly to the fact that the ditches were not so constructed as to withstand the action of time, they have become more or less inefficient, and much of the land has reverted to its former swampy character.

The land of this village, and that adjoining it, being made "high and dry," as it readily may be, it will probably be unnecessary to do more with the simple object of removing agencies tending to create or to foster *fever and ague*.

The influence that such communities have in the propagation of typhoid fever, and other zymotic diseases, renders it important that this work be supplemented by an efficient and well-administered system of local or district sewerage. The household wastes may be disposed of by the method that was suggested in the case of the village of Abbotsford, or, which seems here more feasible, it may be carried through a six-inch earthen-ware sewer pipe to the Hudson river, in connection, if this is desirable, with the drainage of other property along the route. Should the latter method be approved, all the houses of the village may be drained directly into the sewer, and this may be kept clean by the action of a large automatic flush tank, supplied with water by a one inch pipe from the brook above. If this flush tank is made large enough, having a capacity of say 5,000 gallons, the discharge of its contents through a four-inch siphon would have a sufficient scouring effect to cleanse the whole sewer thoroughly at least twice a day, and to carry its contents quite through to the Hudson river. The use of ash closets, or earth closets, should be made compulsory, and proper attention to these, as well as to the removal of dry garbage, should be ensured by proper inspection. Due provision being thus made for the removal of the dry and liquid wastes of the household, it will only remain to abolish all such sources of fouling of the ground as hog-pens, and badly kept stables and poultry yards, to make this village as healthy a place of residence as though it were located on the driest hill-top in Westchester county.

Concerning the course of this brook after it crosses Broadway, it is not necessary for me to say more than that

it should be made to afford a permanent good outlet to the deepened culvert under Broadway. The work is in the hands of the engineer of the Deaf and Dumb Asylum, and will doubtless be properly executed. I must, however, express the hope that their improvement will include such a thinning out of the trees, and other growth which border the brook throughout much of its course on the Asylum property, as shall secure a thorough aeration and sunning of the tract through which it runs.

A considerable branch of this stream takes its rise in a spring south-east of Gurnee's house, which spring is conducted by an underground channel to a well-conditioned pond of considerable size on the high land. The outlet of this pond, for some distance, is by a covered channel. From the lower end of this to the pond on Merritt's property, east of Broadway, the stream runs mainly through a fairly good natural channel, but it would be improved by being deepened and rectified, and it would be decidedly better that the wet tracts bordering it on the north side, south from Gurnee's house, should be efficiently drained,—a header drain being run along the hill to collect the water which now breaks out in springs at the upper edge of these tracts. If the supply of water in this brook is what the character of the pond above-referred to would indicate, there is no doubt that very simple work in the way of straightening, and providing a suitable bed for the stream, will be the only improvement required.

Merritt's pond is, in my opinion, too high. It cannot fail to have an unfavorable effect on the low land by which it is bordered on the south-west. I recommend that its water level be reduced at least eighteen inches by lowering its outlet. This lowering of the water will probably make it necessary to deepen its bed to a slight extent; at least so far as to secure a uniform depth of not less than three feet.

After crossing Broadway the brook passes through Merritt's property and a portion of Terry's by an under-

ground conduit, which seems to be in satisfactory condition. Parts of the triangular piece of Terry's property, between the Aqueduct and Broadway, are too wet, but as the culvert under the Aqueduct is sufficiently low it will be an easy matter to provide a satisfactory outlet for all water having its source either in this brook, in any leakage from the Aqueduct, or in the wash from Broadway, and to put the land in a dry and sound condition. The present dam at this point should be removed.

Terry's ponds, in the course of this brook, are ingeniously devised and carefully constructed. Supposing them to have a sufficient summer water supply, the chief criticism that I am disposed to make concerning them is that the water level, especially in the large lower pond, is too near the surface of the ground. The immediate borders of this pond, and of the island which it contains, are certainly too wet to be wholesome. In my opinion, this immediate district would be healthier, and in every way better, if the thick growth of trees, with which it is now covered, were considerably thinned out. The outlet of Terry's ponds and the main line of the brook which flows around them is through a good underground conduit which delivers the water on to the Asylum property where it is being provided with a deep channel by work now going on.

SECTION 6.

HOLMES'S BROOK.

This brook takes its rise in swampy land, high up on the hill north of Benedict avenue. Its condition is satisfactory until it crosses this avenue. North of the avenue, and just west of the crossing, there is a small swampy tract which it would be well to drain and clear up.

After crossing Benedict avenue the brook enters Stewart's land, which slopes rapidly to the west. The natural course of the brook follows a broad and shallow ravine, which has been ingeniously and perversely converted into three large ponds—much too large for the dry-weather flow of the stream, and all of them eminently objectionable. They follow each other in quick succession, and a considerable portion of the boundary of each pond is a huge artificial mound of earth, supplemented with more or less stone work. These barriers, in places, leak and are in bad condition, all tending to moisten the ground below them. This condition is conspicuous with reference to the dam of the lower one of the three ponds, where on the last of November, notwithstanding the heavy rains of the week previous, no water was flowing over the dam, and a copious flow was leaking out at several points below it.

These ponds are to be regarded as decidedly prejudicial to health, and there is no way in which they can be made harmless. I recommend that the dams and embankments be entirely removed; that the valley be restored to its

original condition and brought into wholesome grass; and that the brook be continued through their present beds by a deep, stone-guttered channel, with well-sloped and sodded banks. The ram which is now driven by the water of one of the ponds may be efficiently supplied by sinking a cask in or near the course of the brook at a sufficiently elevated point. On the day of my last visit (December 3d) the land between the stable and the lower pond, that between the stable and the hill toward the house, and that south-west of the stable, was springy and almost swampy. Evidently, no inconsiderable amount of water, escaping through the dam, finds its way through the cellar of the stable. The spot south-west of the stable is especially bad. The whole condition of this tract may be efficiently rectified by simply continuing the brook through a channel of the prescribed form with a depth of at least three feet below the general level of its banks, and carried by the most direct practicable course through all of this wet land. It is possible that even after the removal of the dams, one or two original springs in the vicinity of the stable may remain active: if so, these may easily be led to the bed of the brook by two-inch tile drains.

From this point to the first pond on Hoe's land, the brook has considerable fall; but its channel is obstructed by stones, and roots, and bushes, and weeds, and its flow is often impeded by the sudden deviations of its course. At several points it is bordered on one or both sides by strips of low, wet lands which are made wet, in some cases, by the water of the brook itself, and in others by the inflowing of spring water from the hill. The northern part of Hoe's eastern field, between Benedict avenue and the brook, obviously needs draining. On the occasion of my last visit, I found considerable areas of this field covered with standing water, although the rain had ceased twenty-four hours before. The draining of this land, aside from its agricultural advantage would have,

presumably, a good sanitary effect. It will not be possible along the whole, nor indeed along any very considerable stretch of the brook between Stewart's stable and Hoe's pond, to adopt the exact method prescribed for brooks running through level or smooth land. It is only necessary to say, in a general way, that the brook should be deepened wherever this is practicable; and that it should have, except where it passes over rocky bottom, a well-paved bed, not to exceed 18 inches in width, and that its banks should be protected by sodding or by stone work. Especially should all bushes be cleared away from it, and all springs and marshy tracts should have their water led directly to it by sufficient deep ditches. Although no uniform system of rectification can be adopted for this part of the brook, it will be easy to bring it into wholesome and satisfactory condition, and to deprive the land bordering on it of its present objectionable wet and overgrown character.

Between Hoe's farm-road and his western line—the Croton Aqueduct—much work of an expensive character has been done, including the construction of four ponds, which are wholly, or in part, surrounded by excellent masonry. The low land near them has been drained, though there are now some indications of dampness. I cannot say that there is a decidedly objectionable condition at any point. At the same time, the land above the upper pond is wet and cannot well be made sufficiently dry except by lowering or removing the dam of that pond; and the same may be true to a less degree of some portion of the land adjoining the second and fourth ponds. The third pond is too shallow, and it and the brook near it are polluted by washings from a poultry yard to an objectionable extent. Certainly, if there were no point in the district under consideration in a worse condition than this portion of the course of the brook, there would be no reason to suppose that malaria, if it existed, was caused by local conditions. I make the foregoing suggestions, not because I consider

them absolutely necessary to the securing of the object now in hand, but because I believe that they constitute a material improvement. So far as the land south of the fourth pond is concerned, the one nearest to the Croton Aqueduct, if it should be deemed necessary to drain it more efficiently, it may be drained to an outlet near the culvert under the Aqueduct, without lowering the level of the pond. These ponds, except, perhaps, the first or highest one, are too small to be considered especially detrimental on the score of evaporation.

The brook and pond on the property between the Aqueduct and Broadway, are also in good condition; but the land north and south of this line seems to be unduly damp. From its situation it may be satisfactorily drained to the culvert under Broadway, without disturbing the pond; though this, from its height, is doubtless in part the source of the moist condition.

After crossing Broadway the brook enters Lewis' land, and almost immediately spreads out to form two ponds of considerable size. These are surrounded by excellent walls of masonry, and if they can be kept sufficiently deep (three feet) will offer no serious objection, save that they have considerable surface for evaporation. The small water-way by which the overflow of the upper pond is carried around by the channel to the north into the lower pond, needs improvement; and a decided thinning out of the enclosing trees is most advisable.

From the lower one of these ponds, down to the road which borders Smith's property on the east, and, in the main, as far as the projection of the west line of Smith's house, the brook is in good condition with well kept banks and bed, save for the existence of three ponds, which, considering their situation in a shaded ravine, it would be advisable to remove entirely. The second of these ponds, that near the foot of the road above referred to, has hardly more than six inches depth of water, and is, in my belief, an objectionable neighbor for the houses

about it. I am decidedly of the opinion that it would be best to clear away all dams in the course of this part of the brook, and thence to the railroad to give the stream as free and direct a flow as possible; removing all removable obstructions, straightening the course so far as practicable, securing a good stone-paved bed for the flow to ensure a rapid run throughout the whole ravine. Smith's ram may be supplied with water without difficulty by the use of a short pipe leading from a cask set in the course of the brook. Between this dam and the river there are several points where the land bordering the stream is unduly wet and springy. This condition it is important to remove, either by cutting off its springs and giving them an outlet at a point lower down the brook, or by lowering the brook itself and draining the springs directly to it. In the lower course of this brook, it is entered by two or three vitrified sewer pipes, carrying laundry and water-closet waste, which condition is eminently and fatally objectionable. All such foul drainage should either be carried direct to the river or be disposed of, by absorption drains or otherwise, upon the property where it is produced.

The part of this ravine near Lewis's house is sufficiently open and its banks are well-covered with grass, but lower down it is in many places too densely shaded and too much shut out from the circulation of air. If free access can be given to sunlight and wind, the ponds destroyed, the bed of the brook put in good condition, and the wet places along its banks drained, it seems to me that every local cause of malaria will be removed from the vicinity of the houses lying north of it.

The outlet of the brook, by a fall over a ledge of rock and through a culvert of which the bottom is up to high water mark, is all that can be desired.

SECTION 7.

THE RIVER FRONT.

It is only restating the generally accepted belief of all who reside in malarious districts along the Hudson river, to say that, without doubt, the building of the railroad embankment across the mouths of the bays or indentations of shore, thus impounding water which formerly had the free sweep of the waves, has been the first great cause in the production of malaria wherever, throughout the whole district, it exists as an epidemic. All experience, observation, and accepted theory point to the truth of this belief. It would hardly be imprudent to say that in so far as fever and ague has become epidemic along this high, airy and generally well-drained district, it has taken its origin in these bays, and has followed the favoring courses which wet ravines and dense vegetation have afforded, to invade the smaller swamps or damp tracts farther inland. Indeed, there is some reason to suppose that in many cases the existence of malaria at a distance from the shore, where there is not a good intervening belt of trees, may be due to the wafting inland of morbid influences from these starting points. Instances without number have been observed in various parts of the world where malaria, obviously originating on the low and ill-kept banks of rivers and ponds, has had far less influence at its point of

origin than on the hill-sides above them and some distance away from them.

In seeking a theory concerning these bays, it is instructive to recall the conditions existing on the Schuylkill River, Philadelphia, early observations of which, by the elder Dr. Pepper, have been kindly communicated to me, together with his own more recent ones, by his son and professional successor. They are substantially as follows :

The Schuylkill River was originally quite a rapid, shallow stream. Malaria was entirely unknown along its banks, and it became the favorite resort of the wealthier class of the population who lined its banks on both sides, and for some distance, with the finest country seats. Subsequently, in the construction of the Water-works for Philadelphia, a dam was built across the river at Fairmount, setting the water back for a long distance up the stream. Within a short time after this, aggravated malaria was developed, which became so serious and severe as to lead to the practical abandonment of the banks as a place of summer residence. Dr. Pepper believes that this effect was clearly due to the fact that the stagnant water overflowed the former banks for a considerable distance, and submerged ground which was rich with an old accumulation of vegetation. As the level of the river constantly rose and fell with varying rain-falls, and in different seasons, the alternate exposure and saturation of this ground generated malaria. Some years later, a line of steamers was put on the river above the dam, and it was soon noticed that the frequent agitation of the water and the sweep of the shore by the following waves of the boats washed away much of the decomposing vegetable matters, and caused a very marked diminution in the amount and in the severity of the malarial diseases. Still later, as the manufacturing industry of the city increased, factories were built along the banks of the Schuylkill, and factory villages became numerous and populous. This led to a very filthy condition of the banks ; all man-

ner of organic matter being deposited upon them, and malaria again increased. Doubtless the upturning of soil in the building of the mills, roads, etc., added to this effect. A few years since, with a view to purifying the sources of the city's supply of water, the banks of the Schuylkill and of its branch, the Wissahickon, were taken by the city for a public park, and came under the energetic control of the Park Commission. The factories were removed. The population which had surrounded them, mainly went with them, and the most careful policing of the shores was rigorously and effectually carried out; so that malaria has finally not only decreased, but almost entirely disappeared.

Before the building of the Hudson River Railroad, no matter what decaying vegetation or other foul matters might be deposited upon the shore of the river within reach of the tide, it was quite sure to be washed away by the frequent action of the waves, while the regular covering of the shore with salt water prevented the growth of any abundant aquatic vegetation. After the building of the embankment, the action of the waves was entirely shut off, and the only movement given to the water was by its sluggish inflow and outflow, as the tide rose and fell, through the more or less copious culverts furnished by the constructing engineers—furnished evidently without reference to the effect they would have upon the bays enclosed, but only as measures of security for their own work. Little by little the earth and rubbish from the upland accumulated in these bays, raising a considerable portion of their edges above the reach of ordinary tides, and there sprung up a fresh-water growth of cat-tails, alders, bushes, etc. This, accumulating year by year, and increasing always the amount of injurious material, and raising the edges, and in some instances, nearly the whole area of these former bays, produced a condition akin to that of the shores of the Schuylkill, after the raising of the water-works dam. They are alternately wet and dry; they are

largely composed of decaying vegetable matter, and they seem in every way to favor the production of the most malarious conditions of the atmosphere over them.

In one respect they are very much worse than any condition of the shores of the Schuylkill, though, being relatively of less extent, it is not to be presumed that the intensity of their effect is correspondingly increased. There is no doubt that the regular covering, even of muck deposits, by ordinary tides, where the salt water is not mixed with fresh water, the salt acts as an antiseptic; and purely salt marshes are rarely the source of malaria. But there is ample recorded observation to show that however bad may be the effect of the decomposition of vegetable matter, alternately exposed to the air and covered by water, on the banks of fresh water streams and ponds, this effect is greatly intensified, and all the malarious conditions are seriously aggravated by an admixture of salt water with the fresh—perhaps because the fresh water existing there, or coming from higher land, contains a considerable amount of algoid vegetation peculiar to fresh water, which even a slight admixture with salt water causes to die, thus increasing the amount of decomposable organic matter.

Russell, in an article on "Malaria," *Pop. Science Monthly*, Vol. X., p. 419, says: "Localities subject to the intermixture of salt and fresh water are peculiarly prone to malaria." He cites the case of the Maremma of Lucca—marshes containing pools of fresh water which were frequently invaded by the tide. Malarial fevers made the whole district almost uninhabitable. In 1740, the sea was excluded from the most unhealthful marsh. The fevers were entirely removed and the district was made salubrious. Viareggio—previously abandoned—became a fashionable resort. In 1768-9, the work having become defective, and the admixture of water again taking place, the fevers became again as bad as ever. They were once more removed by restoring the barrier against the sea.

In 1784-5 the sea water found renewed entrance, and out of a population of 1900, 1200 had malarial fever. A restoration of the works restored the healthy condition. Other portions of the Maremma were subsequently rescued by the same means.

Whatever the theory as to the process, the certainty of the effect is not to be doubted. Any serious attempt to remove these gravest causes of any malaria which may exist in the Irvington district must have in view the removal of the following conditions:

1st. The existence of a soil rich in vegetable matter, which is either constantly moist or alternately saturated and exposed to the air.

2nd. The existence of shallow, stagnant water of too little depth to keep the heat of the sun from producing decomposition, or fostering low forms of vegetable growth at its bottom.

3d. The entrance of salt water for admixture with the fresh water existing upon any such land.

If these three conditions can be removed, I believe that the production of malaria at these points will be obviated. I also believe that in the case in hand they *may* be easily, effectually, and permanently removed.

It has been one of the most satisfactory results of my examination to find that in a great majority of cases the desired end may be accomplished without resorting to the very expensive and troublesome device of filling these bays to a considerable depth.

Along the northern part of Wilde's front there is an especially bad flat about 625 feet long and 50 feet wide at its widest part. Its lowest point is two feet below ordinary high water. Its only means of outlet is through a small culvert 18 inches below high water, so that it always retains water and receives an accession of river water at every tide. It is much overgrown with foul vegetation, its bed is largely composed of decayed rushes and leaves; and, save for its distance from any house, espec-

ially in the direction of the prevailing winds, and for the protection afforded by the closely overgrown bank. east of it, it is to be regarded as bad and dangerous.

I recommend that the culvert now existing under the old part of the railroad be put in good condition to the depth of low water, and that it be continued to the same depth under the new or eastern track, its shore end being closed by a wall of cemented masonry and carried higher than *the highest spring tides*, so that the entrance of river water shall become impossible. The water coming down Wilde's ravine during storms should be kept from entering the low land by an embankment, and should have an outlet through a tide gate constructed in the upper part of the dam, barely low enough for the flow. At the level of low water the dam should be furnished with an six-inch pipe, having a tight flap valve opening outward, and having attached to its inner end a second effective backwater valve also with a six-inch water way. This double protection is advised for the reason, that, while a flap valve is ordinarily effective in excluding the water of a rising tide, the accidental introduction of a twig or other substance between the valve and its seat might hold it open sufficiently far for a considerable inflow of water. In such case the second valve would prevent the entrance of this water into the drain behind it. The admission of river water being thus excluded, and a free outlet being furnished for the drainage of the flat, I recommend that a broad ditch with grassed sides, running six inches above the level of low water, be carried through the whole length of the swamp. As there is no considerable source of water from the upland—no stream and no strong spring—the bottom of the ditch will probably not be too wet for a growth of grass; certainly only its immediate bottom will be too wet for a good permanent growth. Any depressions in the swamp from which the water does not naturally flow toward this ditch should be connected with it by lateral water courses.

sloped like the main ditch in such a way that the grass may be easily mown and kept in order. This and the proper cultivation of the surface, after the work is completed and after the accumulated decaying organic matter has been removed or dug into the ground, is, in my opinion, all that will be required to convert this particularly bad stretch of the river front into a satisfactory and entirely inoffensive meadow.

The northern part of D. Field's river front is occupied by a portion of a swamp similar to the one just described, and of which the upper half on Cottenet's front has been filled nearly to the level of the railroad track, and put in good condition. The outlet of this swamp is through a **very** large culvert under the railroad, and all that is needed, in the way of improvement, is to build a well-cemented stone wall across the inner end of the culvert provide a suitable double-valved pipe, as above described, and to treat Field's portion of the swamp precisely as recommended for Wilde's. The condition of Cottenet's artificial meadow is now so good that no danger is probably to be apprehended from it—certainly none, if the salt river water is prevented from soaking into it, by the means above indicated.

A considerable part of Schuyler's front was evidently at some former time since the building of the railroad in very much the same condition as Wilde's swamp. A considerable part of this swamp has been filled in to a sufficient height for perfect drainage, its western edge being bounded by a good dry wall. Between this wall and the railroad embankment, for a width of from 5 to 15 feet, and a length of about 700 feet, lies a portion of the original bottom, which, though of small area, combines nearly all of the unfavorable conditions to be found in the larger and more neglected swamps at other points. It contains a considerable accumulation of decayed or decaying organic matter and a decidedly injurious amount of aquatic vegetation. In addition to this, nearly the whole

bottom is saturated with the water of the river, at every rise of the tide, and exposed at every fall of the tide. It has no stream of moment running into it, and its complete rectification may easily be effected by the construction of a cemented stone wall in front of the culvert, provided with the device described above for excluding the tide-water. The whole bottom is sufficiently high to be efficiently drained through the low water flap-valve and the whole area may very easily be brought into good and wholesome grass. In my judgment, nothing further will be needed for its complete rectification.

In front of D. N. Barney's place, the former swamp has been filled and brought into grass, but without adequate drainage. It is now reverting to a swampy condition and cat-tails and bogs are appearing. Its sanitary condition is bad now, and it is evidently growing worse. Its lowest point is about one and one-half feet above high water, and the culvert by which its water escapes is six inches above high water. It is probable that spring tides flow in through the culvert and saturate the soil. I recommend that the culvert be lowered at least two feet, that its inner end be tightly closed and provided with a double valve pipe as above directed. This being done, the whole area of the former swamp should be adequately drained with tiles delivering at the above named valved outlet.

The flat at the foot of the Sunnyside road exhibits a bad result of the cutting off of a bay of the Hudson River by the building of the railroad, made worse by an ineffectual attempt to put it into good condition by filling. The whole length of this flat from its south end on Tiffany's land to its north end on the Irving property is about 1,500 feet along the railroad, and the width, for a considerable distance, is 200 to 300 feet.

In its present condition this tract is probably worse in its influence upon the health of those who live near it than it was before any attempt was made to improve it. The theory is very generally accepted that wet soil is

worse than stagnant water as a producer of malaria. This whole flat, with hardly the exception of a square rod, is almost always more or less damp.

It becomes, now, a serious question to decide what means may best be adopted for its improvement. It would undoubtedly be effective to raise its level in every part to nearly the height of the railroad embankment; and then, cutting off all extraneous water coming in from the hills, thoroughly to underdrain the whole area. This however would be an extremely costly operation, and the amount of earth could with difficulty be obtained without defacing some portion of the hill-side.

It seems to me that, in this case, the cheapest way is the best way. It has also the advantage that it may be undertaken at once, and completed before the opening of summer.

My recommendation is as follows:

1. Make new channels for Sunnyside brook, and for Matthiessen's brook, having their beds, at the line of the railroad property, at least as high as ordinary high-water mark. The artificial channel thus constructed should be proportionate to the amount of flow to be accommodated: say in the case of the Sunnyside brook, a paved gutter of circular section, three feet wide at the top, and one foot deep in the middle: and in the case of the Matthiessen brook, 18 inches wide at the top, and six inches deep in the middle. To provide for excessive floods, these gutters should be bordered by mounds of earth two feet high, well compacted and carefully sodded. The course of the conduits should be, in both cases, as direct as possible; any deviation from the straight line should be through gradual curves.

2. At the line of the railroad, each conduit should deliver over the top of a strong dam of cemented masonry, *for the entire exclusion of salt water entering through the culvert under the railroad.*

3. Surface gutters, following the contour of the hill,

should lead to these conduits the surface wash of the steep hill-side between the two brooks, and, so far as may be necessary, from the side toward Tiffany's and the side toward Irving's. In other words, the flat should be, as far as possible, shut off from the entrance of surface-water or brook water coming in considerable quantity from any outside source.

4. The land-water being diverted, and the tide-water being excluded, it only remains to provide for such water as may come to the land by rain-fall, by infiltration through the railroad embankment, or by underground springs discharging below the level of the hill-side gutter. This may be accomplished by a properly-arranged system of underdrains delivering through pipes having snugly-fitted double tide valves and discharging one foot above ordinary low tide—the pipes discharging through the dams above referred to, in front of the culverts.

5. As the discharge must necessarily be intermittent, the flow being held back at each rise of the tide, it will be necessary to provide storage room of greater amount than the contents of any ordinary system of tile drains. For this purpose it would be well to construct in the center of the flat a reservoir, say 10 feet in diameter, built with loose stone walls, having its outlet one foot above the level of low tide; and to lay 6-inch tile drains,—laid on an inclination of 1 in 400,—running directly east and west from the reservoir to within 30 feet of the foot of the hill on one side, and to within 30 feet of the line of the railroad on the other, having a branch running along the railroad as far as the middle of the Irving flat, and for a distance of about 150 feet southerly, also about 150 feet each way along the foot of the hill. Silt-basins should be constructed at the points of intersection. The reservoir should be connected by a straight 6-inch vitrified pipe drain running on a *flat* grade to the valved outlet through the dam at the Sunnyside Brook culvert.

A corresponding arrangement, but of less extent,

should be adopted for the Tiffany and Matthiessen portions of the flat, its reservoir being connected with a double valved pipe through the culvert dam by which that portion is drained. Lateral tile drains, laid at intervals of 20 feet, having a fall of 1 in 200, should deliver at the top of the 6-inch tiles. By this arrangement storage room will be provided to hold water discharged by the drains while the tide is above their level, and at each fall of the tide this storage space will be entirely emptied. The silt-basins and reservoirs can be cleaned out as usual.

The small, unfilled spot at the south-west corner of the Fargo flat may be filled to the level of the other portions of the tract, or it may be sufficiently drained by surface gutters.

Whatever course may be adopted with reference to these lands, the ice pond on Matthiessen's land should *by all means* be abandoned.

I make these recommendations with entire confidence, and have no hesitation in predicting as their result an absolutely good agricultural and sanitary condition of this whole tract.

Almost immediately above this flat, mainly on the Irving property, but extending about 100 feet over Banker's line, is a flat 450 feet long, with an average width of 70 feet, which has been filled to above the level of high tide. Its drainage is discharged through a culvert under the railroad near its northern end, which culvert also carries the flow of the small brook on Banker's property. This flat is very wet and its proper drainage is to be considered as absolutely necessary. It may best be drained on the same principle adopted on for the large flat just considered. But, owing to its small area, sufficient storage room will be given if its whole drainage is effected with the use of three-inch tiles for laterals and six-inch tiles for the main drain, the latter running north and south. This six-inch tile should have a fall of 1 in 400. It should deliver at its northern end into a pipe running

under the railroad to a level of one foot above low water mark, and protected at its outer end with double tide valves. All upland water should be cut off, so far as practicable, and led into Banker's stream which should cross the flat in an elevated channel, so protected as to prevent the escape of its water on to the land, and delivering above high water.

Along the front of Holdredge's property is an enclosed bay of which the low part is between 500 and 600 feet long, and which averages nearly 100 feet wide. Its lowest point is about two feet above low water mark. Its level varies considerably, parts of it having been filled by wash from the adjoining hill. It is all in thoroughly bad condition, receiving considerable water during storms from the land adjoining it, and always more or less spring water. Fully three-quarters of the area is covered by every tide. Near the southern end, for a length of 150 to 200 feet, and for a width of 40 or 50 feet the water stands, even at low tide. There is a considerable growth of aquatic vegetation, the bottom is foul and slimy with mud, there is along the shores a considerable accumulation of decayed leaves, and generally the whole character of the flat is typically bad.

It is of no value to the Holdredge property, being entirely out of sight from the house, and not easily accessible from the higher land. It is to be regarded simply as a nuisance to be abated in the simplest, quickest, and easiest way. I recommend that along the foot of the high land there be constructed a catch gutter to prevent storm water from the hill from running into the flat, and that this be led by the most direct course to the present culvert and discharged at the level of high water. Also that the culvert be deepened to the level of low water, and shut off from the flat by a cemented mason-work dam two feet higher than high water mark, the discharge of surface water spoken of above being through this dam by a valve gate. This being done, run an open ditch two feet deep, through the whole length of the flat, sloping its sides

enough to prevent their caving, and leading to it small runnels to drain occasional low spots at the sides. Connect this open ditch with a double-valved pipe through the bottom of the dam. By this method we shall exclude salt water, keep upland water out on the lower part of the flat, provide sufficient storage room in a longitudinal ditch to hold drainage water exuding between tides, and deliver it into the river at every fall of the tide. This improvement should be followed by a good seeding with grass, or if still too wet for this, by a thick planting of osier willows over the whole area, so that it may be speedily covered with thrifty vegetation.

On Merritt's property there is a swamp shut in by the railroad which is very much of the same character with Holdredge's just described, save that it is smaller and higher; (lowest point six inches above ordinary high water.) It has the added disadvantage of a sewer discharging foul matter into it. Its treatment should be essentially the same as that prescribed for Holdredge's flat. The culvert being shut off by a dam two feet higher than high water mark, the sewer being continued by well-cemented, and well-bedded pipes, across the swamp and through the dam, the culvert being deepened to three feet below high water mark, and a double valved pipe discharging, at this level, the water of longitudinal and lateral ditches sufficient for the effectual removal of surface water. This being securely done, the flat ditch—slopes and all—should be seeded to grass.

On Terry's front, for a length of 350 feet, and an average width of 25 to 50 feet; area about 12,000 square feet; is a cat-tail swamp, which continues for about the same length, but of less width on to the Hoge property. The culvert by which this swamp should be drained is only two feet and three inches below high water-mark. The lowest point of the swamp is one foot and six inches below high water-mark, and most of its area is six inches or more below high water-mark. The washing in from the hill in some parts,

and the accumulation of decayed rushes and leaves, have given some variation to the level of the bottom, and led to the holding back of water, here and there, in stagnant pools. This is especially the case near the extreme end, being out of reach of ordinary tides. Every tide enters the swamp and produces whatever ill effect may be ascribable to the admixture of salt and fresh water. There is no stream entering from the upland, only an inconsiderable spring breaking out under the bank, like the last two swamps described; it is of no value to the property of which it forms a part, and it may best be treated in the manner directed for Holdredge's swamp. The culvert should be deepened to the level of low water, and separated from the land by a high and tight dam, through the upper part of which surface-water should be delivered with a tide-gate; and through the lower part the deeper drainage by a double-valved pipe,—the water gathered in the open drains flowing into the river at low tide. This being done, a good growth of willows or grass will complete the improvement.

At the mouth of the Sheldon brook, on the Hoge property, purchased by the Deaf and Dumb Asylum, is a considerable swamp the middle portion of which has been filled to above high water mark by silt brought down by the brook. At the south end, the land is somewhat lower and contains a pool six inches deep, the surface of the water in which is six inches above high water mark. The north end of the bay has never accumulated sufficient wash and vegetation to fill it. It is now chiefly occupied by a pond which is three feet deep in the middle and of which the surface is one foot above high water mark. At this level it is connected by a sluggish gutter with the brook. My recommendation is, that the dam, which has been partly torn down, be restored and put in good and tight condition; and that so far as the course of the brook crosses the flat it be bordered on each side by a retaining bank, which will prevent it, even in time of flood, from dis-

charging water on to the flat at either side, and which will also prevent the water of excessively high tides from reaching the flat. Those parts of the dam not occupied as the outlet of this channel should be raised to the same height with the retaining banks of the brook.

The swamp being thus divided into two sections, each should be thoroughly drained by open ditches with double-valved outlets through the wall to the level of about one foot above low water mark. It is likely that the whole swamp will, in this manner, be made sufficiently dry for the growth of good grass. This will certainly be the case about the mouth of the ravine where, for considerations of beauty, grass will be important. If the bed of the present north pond should be found too wet for grass, it may be occupied by willows.

Further to the north, there is a swampy flat, 450 feet long and 50 feet wide in its widest part. This has no obvious connection with the river, and probably when the third track of the railroad was built, such communication as it had was obstructed. Its lowest point is two feet above high water mark and its drainage and complete rectification become a very simple matter. By surface drainage, even to the level of high water, it may be made sufficiently dry for the growth of willows, if not of grass; and by tile drainage, with a valved outlet to the line of half tide, it may be easily and cheaply drained in such a way as to make it excellent grass land. This latter course is certainly most desirable from a sanitary point of view, and I suggest the alternative only for adoption in case the slight saving in expense is deemed important.

In front of the line dividing the Hoe and Copeutt property, and extending about equally on to each with a total length of 750 feet, is a bay cut off by the railroad, which has received quite different treatment from any other on the river front under consideration. No attempt has been made to drain or to fill this, but it has, on the contrary, been converted into a permanent pond, by the erec-

tion of a tight dam in front of the culvert. It is surrounded for its entire circumference with a sound wall of dry stone work.

Unless there is some reason, not apparent to me, for suspecting that this pond has had a malarial influence, I am disposed to recommend that it be continued, if, as I have found to be the case, whenever I have examined it, the supply of water is sufficient to keep it full. The border of the pond toward the shore has been somewhat filled by earth washed from the hill-side. This should be removed; and all such washings should, if possible, be prevented for the future. There is also a deposit of silt at the mouth of the brook which is likely to be renewed from time to time. The only precaution that seems to be necessary, is to ensure the drawing off of the pond every year, and the removal, not only of silt brought down by the brook and earth washed in from the bank, but of decaying vegetable matter as well; and the ensuring of a depth close to shore of at least *two* feet, and a depth of at least *three* feet at a very short distance from the shore. These directions assume that the present dam is high enough to prevent the invasion of river water, even at the highest spring tides. If this is not the case it should be raised so as to make it certain that no salt water will at any time enter the pond.

The large bay at the south end of Tarrytown is not properly included within my district. But, having seen the recommendation that it be filled to the level of the railroad track, it has occurred to me that it could probably be brought into good sanitary condition by draining it to the level of low water, and then filling sufficiently to bring the whole bed three feet above the lowest drainage level. This would leave the whole tract too low for wholesome building lots, but it should entirely remove its unfavorable influence upon the population living near it.

NOTE.

In the foregoing comments on the work considered desirable to be done with reference to the supposed malarial conditions of this district I have included all that seems to be of public importance, or rather, all work which requires the concurrent action of different land-owners. My notes cover a very careful description of every part of the territory, and it would be possible, by materially increasing the length of this report, and by giving publicity to much that is of only private interest, to set forth a number of particular cases where small tracts of wet or damp land should be drained, where shrubbery should be removed, or thinned out, where plantations which prevent the free circulation of air about dwelling houses should be removed, or thinned, and where, in my judgment, a dense shading of the ground is liable to afford a resting place for malaria. As in such cases the propriety and advisability of carrying out my recommendations is to be decided by the individual owner, and as the defects are not of sufficient extent or intensity to affect the general salubrity of the neighborhood, I have deemed it best to omit this whole part of the subject from my public report.

I shall be glad, on the application of any owner, to inform him professionally what I deem it advisable for him to do with reference to the points above named—this, of course, without charge, and as a part of the service for which I am employed.

THE SEWERAGE OF IRVINGTON VILLAGE.

Complete sanitary work at Irvington must include the provision of some suitable means for removing the household wastes of the village lying between the railroad station and Broadway.

In view of the excellent and easy means of discharge afforded by the river, no other available method would be nearly so good as discharge through vitrified drain pipes, having well cemented joints.

These pipes should be, in all cases, except from the railroad to the outlet, six (6) inches in interior diameter, not because the sewage produced by the houses of the present (or probable future) population will be sufficient to require so large a pipe (on such a slope), but because adequate ventilation cannot be secured with smaller pipes. The outlet—west of the railroad—should be of eight (8) inch pipes.

The objection which recently existed to the adoption of pipe sewerage in villages not abundantly supplied with water has been entirely removed by the introduction of Roger Field's Flush Tank. This is a reservoir for holding back the sewage of a few houses at the head of each line of sewers (together with rain water from a portion of their roofs) until the chamber becomes filled. The flow then brings into action an automatic siphon by which the retained liquid is shot rapidly into the sewer, causing a sufficient flushing current to carry forward to the outlet all solid matters which may have been deposited in it by house drains entering it farther down its course.

In the accompanying plan, which shows the location and course of the main sewers and their branches, I have located a flush-tank of considerable size at the upper end of each main sewer, and a smaller flush-tank at the upper end of each branch sewer.

As the annular siphons of these flush-tanks will not admit solid substances large enough to obstruct the flow through a six-inch pipe, no "man holes" will be needed.

The point of outlet is fixed under the bridge near the end of the dock west of the R. R. station.

This outlet should be open to the air at all tides, or a separate air inlet should be provided. Every house connected with the sewer should furnish suitable means of ventilation by a soil pipe, or other pipe opening above its roof.

All house connections should be through four (4) inch pipes.

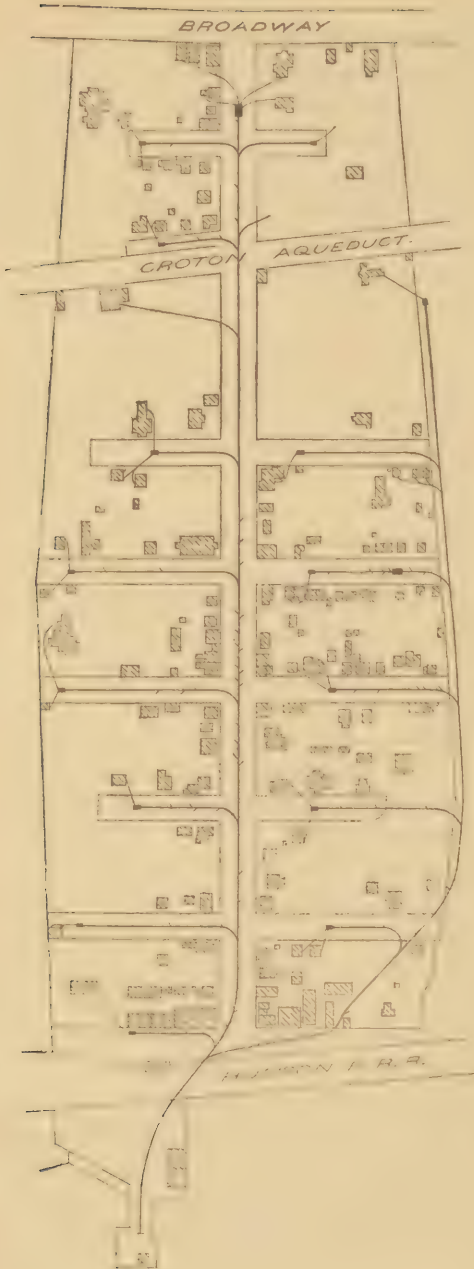
The depth of the sewers should be about five (5) feet below the level of the streets, except when a less depth may be necessary in crossing the aqueduct, or in traversing the level ground near the river.

Owing to the exceptionally low prices now prevailing, I have been able to get bids for the complete work, excepting house connections, which indicate the propriety of contracting for it at once.

The total cost of main sewers, branch sewers, junction pieces for house connections, and all flush-tanks, and for engineering expenses and supervision, need not exceed \$2,585, unless rock-cutting should be necessary, or \$17.83 for each of the 145 houses in the sewer district.

If these sewers are provided, and if house connections with them be made, in all cases, compulsory, and if all privy-vaults, cesspools, hog-pens, &c. be abandoned, there is no danger that zymotic diseases will be caused by the use of water from the wells of the village.

The present sewers on the main street will still remain useful for the removal of street waste, but they should be



PLAN OF SEWERAGE FOR IRVINGTON VILLAGE

so far amended as to afford a *continuous smooth channel* for their contents. At present, as I am informed, they are not continuous, but have occasional large, and rough, floored chambers, where the original excavation through rock has been made to serve as a channel without the use of pipes. This condition is detrimental to health, and it should be changed whether a new system of sewers for house drainage be provided or not.

G. E. W.





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